Study of energy and non-energy uses of biomass resources and development of biomass management plans for selected villages in the Irgad micro-watershed in Pauri Garhwal district of Central Himalayan Region

Interim Report

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CHAPTER 1
Introduction

The stress on the biomass resources in the Himalayan region is a major cause of concern because of the fragility of the eco-system, and also due to subsequent environmental impacts. The use of woody biomass for energy and non-energy end-uses has been identified as one of the factors causing stress on local biomass resources. The interventions designed to improve either the energy or the environment situation in the area need to be understood to address this stress.

An earlier exploratory study in this regard in the Garhwal area revealed that the use of woody biomass to meet energy needs in a village can cause stress on the resources within the village. The Department of Science and Technology has supported a centre at Pauri, to set up a district level database to assist in Natural Resource Management. In addition to water, biomass is a major resource in the region. The present study has been designed to focus on a small region in Garhwal i.e. Irgad micro-watershed to undestand the nature of local biomass supply systems and the pattern of their usage.

1.1 Objectives

The specific objectives of the study are

1/ To identify systems for biomass production based on the access and collection of biomass in selected villages of Irgad micro-watershed in Pauri district.

2/ To assess the availability of biomass resources.

3/ To study the consumption of biomass in order to compute the stress caused by energy and non-energy uses.

4/ To develop a database and a software to assist in analysing the data and in developing an optimal biomass management plan.

5/ To develop a 20-year biomass management plan for each of the surveyed biomass systems in order to achieve optimal utilisation of biomass resources.

6/ To provide training to local officials/people in development and implementation of the biomass management plans.

1.2 Scope of the report

The report includes the details of work carried out during April 1991 to March 1993. In Chapter 2, the methodologies adopted have been discussed in brief. This section also covers the modifications made over the prescribed methodologies to suit various field situations, a general guideline to develop a biomass plan, and a section on various norms used in different calculations. The details about the study area and selected villages is included in Chapter 3, which also includes the procedure followed in selecting the sample villages.

The progress so far made in the study has been depicted in Chapter 4. It includes the progress in fieldwork, software development, data analysis, and in developing future plans for the forthcoming year. In Chapter 5, the results obtained after analysing the information on biomass supply as well as consumption, are discussed. The household questionnaire, various regression equations, codification to the software, list of local species, and results on biomass supply situation are given in different appendices.

CHAPTER 2
Methodology

In this study, trees, shrubs, grass, crop residues and cattle dung were the considered biomass resources. The procedures used for identifying system boundary and for assessing different biomass resources have been detailed in following text. Stress on various biomass resources i.e., cow-dung, shrub, grass, agricultural residues, and trees caused by various energy and non-energy enduses was computed. To make an accurate estimate of the biomass supply and its consumption, primary and secondary information was collected.

Primary information was collected by using various equipment and questionnaires, and in few households the data gathered by questionnaires was cross checked by measurements. Secondary data was sought from Revenue Department (Patwari), Forest Department, Census, Village Pradhan as well as Van-Panchayat Pradhan.

The documents pertaining to land settlements were studied at the district headquarters of the Revenue Department. At the Forest Department (Reserve) office, documents were studied to gather information on the forest area, dominant species and the quantity of timber released to different villages against their rights and concessions as per the Nelson's Forest Settlement (1917). Local productivity figures for various rabi and kharif crops were taken from the computerized district database. Table 2.1 summarises the methods used for collecting data on different information items.

The information thus collected was processed using the methodologies and formulae detailed in this section. The present chapter also deals with various norms used in different computations.

Table 2.1. Methodologies for collecting data

Information	Methodology Used	Level	Source
1. ***Cattle Dung***			
a) Livestock	Questionnaire	Family	Family
b) Dung production	Primary survey	Family	Family
c) Dung used for cakes[*]	Primary survey	Village	Family
d) Dry to wet wt, ratio[*]	Primary survey	Watershed	Family
2. ***Agricultural crop residues***			
a) Grain to straw ratio[*]	Primary survey	Watershed	
b) Productivity of crops	Secondary data	District	Data centre, Pauri
c) Area under various crops	Secondary data	Village	Patwari
d) Total area under a crop	Calculated	Village	
e) Total agricultural land	Calculated	Village	
3. ***Grasses***			
a) Bheeta land ratio[*]	Primary survey	Watershed	
b) Village common land	Secondary data	Village	Patwari
c) Productivity[*]	Primary survey	Watershed	
d) Share as per settlement	Calculated	Village	
e) Total agricultural land	Calculated	Village	
f) Bheeta land	Calculated	Village	
4. ***Shrub***			
a) Productivity	Primary survey	Watershed	
b) Dry to wet ratio	Primary survey	Watershed	
5. ***Trees***			
a) Girth at Breast ht (Tree)	Primary survey	Stratum	
b) Height (Tree)	Primary survey	Stratum	
c) Basal area	Primary survey	Canopy	
d) Species	Primary survey	--	
e) Area under canopy	Secondary survey	Canopy	Patwari

To be developed as standards.

2.1 Biomass system identification

Depending on either abundance or scarcity of the biomass resources people have been known to move out of the village boundaries for fuel and fodder. Hence, often the biomass system being exploited by a village spreads beyond the village boundary and needs to be identified separately for every village before starting the survey to assess the resources.

People have access to biomass outside village boundary if

(1) they enjoy rights and concessions on other land categories;
(2) they purchase biomass resources; and
(3) they obtain the resources illegally.

Rights are earned due to ownership of agricultural land in other villages whereas concessions are granted as per the land settlement[1] on revenue as well as forest land. The other two methods depend on availability of the resource in the market and on chance. These are not considered while identifying the system boundary. However, their use will be reflected in the consumption and will add to the stress on the resource.

Finally, the area in a village level biomass system was calculated as:

Area in a village level biomass system = Area in the village + Area as per land settlements + Agricultural land owned outside the village - Agricultural land owned by outsiders

This biomass resource would only be an estimate of the potential biomass supply legally available to a village from local resources.

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[1] **Land Settlements:** Depending upon the prevailing practices all the villages were given some concessions and rights to harvest forest as well as revenue land. Concessions on forest land were approved by the Nelson's Settlement (1913-17) and on revenue land it was done by the Abotson's Settlement (1926-40).

There were different types of sharing patterns for various biomass sources among the villages. This might lead to a need for clubbing of villages for developing a biomass management plan. Some of these patterns of sharing are described here to assess the necessity of clubbing various villages and separating the independent biomass systems.

2.1.1 Share of biomass from forest land

The area as per the land settlements was not easy to calculate, specially for a forest settlement. A land settlement record lists the name of the villages which has the right to harvest a resource but does not specify the area from which the harvest may be removed. So it was not possible to locate where and how much area was being harvested by a particular village. In the absence of this information, the biomass system becomes more indicative of qualitative rather than accurate quantitative information.

To account for the wood being harvested from the land (where settlement exists but area could not be computed) it was decided to calculate the share of individual villages harvesting the biomass on the basis of the number of families by using the following formule:

1. Grass

$$\text{Share of village 'A'} = \frac{\text{No. of families in village 'A'}}{\text{Total no. of families harvesting the common land}} \times \text{Area of the common land} \times \text{grass productivity}$$

2. Shrub

$$\text{Share of village 'A'} = \frac{\text{No. of families in village 'A'}}{\text{Total no. of families extracting wood from common land}} \times \text{Area of the common land} \times \text{shrub productivity}$$

2.1.2 Share of biomass from revenue land

Sharing agricultural land

People of one village may own agricultural land in other villages and outsiders might own land in the village and share various biomass growing on agricultural fields (if cultivated by the owners). Biomass shared and transported to a village could be calculated, so the agricultural land in villages sharing various biomass should not be clubbed. This holds good even in the case of an unhabitated village where various other villages had agricultural land e.g. the agricultural land in Kandli was owned by the people of village Jairaj, Nisni, Doblya, etc.

Sharing whole of agricultural land

Though it was observed only in one village i.e. Jhaketi, (an unhabitated village) that whole of the agricultural land was owned by only one village i.e. Thapli. Moreover, the only family residing in Jhaketi had shifted from Thapli, so whole of the biomass was being consumed by village Thapli. In such a case, it is not required to calculate the separate shares of the different villages, and all the natural resources may be clubbed to estimate the potential sustainable supply.

Sharing a village forest

Generally, the Van-Panchayats announce the days and the number of headloads each family would be allowed to harvest every day. This way the share being extracted by a village was very clearly mentioned. In the absence of the documentation, proportionate share might be computed. This way the resource harvested by the village Suraj Dhulli, and Bisht Dhulli is calculated.

It is evident that as long as there is either partial sharing of the natural resources or the share of the sustainable yield to a village could be computed, villages should not be clubbed.

2.1.3. Land under an agricultural crop

Villagers harvest crop residues from their agricultural fields owned in the village as well as fields in other villages. The formula adopted to calculate the total crop residues was applicable only when the area under a crop was determined. Area under a crop includes some of the agricultural land of the village as well as some land in other villages. Area under a crop in a village was well documented but it was not easy to determine the crops being grown in the agricultural fields owned in other villages, except if one surveys the fields. It was assumed that in all such fields, crops were being grown in the same proportion as depicted in the Goshwara (record for the crop-wise land use) of the village. To calculate the proportion it became essential to assume that the sum of the land under major kharif crops (Rice, Jhangora and Mandwa) was the total agricultural land.

The total area under a crop is calculated by using the following formula:

Area under crop 'A' = Area under 'A' in the village + Area under 'A' (owned by the village) in other villages - Area under 'A' owned by others in the village.

$$\text{Area under crop 'A' in other village 'X'} = \frac{\text{Total area under 'A' in village 'X'}}{\text{Sum of agricultural land under major crops in village 'X'}} \times \text{Total agri.land owned by given village}$$

By taking the above mentioned assumptions and using the formula, the area under a crop and crop residues from that crop can be computed accurately.

2.1.4 A miscellaneous land

In some of the villages it was observed that the private land was being used for common benefits. For instance, the agricultural land owned by the villagers of an unhabitated village, was generally occupied by the people of the village for cultivation or it was harvested by all. Such private lands were a part of the biomass system and were never accounted for. Such land should be considered as miscellaneous land and entered in the relevant file so that the area may be accounted for while calculating grass and shrub production.

2.2 Estimation of biomass supply

2.2.1 Tree

All the village land was classified into three strata i.e. homestead, agricultural land and village forest land. All the trees on different strata were identified and measured for girth at breast height (GBH) as well as height. All the young crop, either natural regeneration or plantations, was observed for different growth parameters on all common lands. For stands dominated by trees, observations regarding basal area were made by Wedge prism and crop height was measured by Ravi multimeter.

Growing stock of stands can be determined by the following formula:

Growing stock (per ha) = Average basal area x Crop height x Form factor x Area (ha)

For major species[1], volume was estimated separately, however all miscellaneous species[2] were clubbed together and volume was estimated by Regression equation method. The regression equations are listed in appendix 7.

Using the height (H) and girth (G) for the trees in various selected villages, regression equations were built to compute height of all the trees in each species. The general equation used was:

$$\mathbf{H = a + b \times G}$$

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[2] Major species were those, which contributed at least three per cent to the total basal area.

Miscellaneous species include:

(1) All species contributing less than 3 per cent of total basal area.

(2) All fruit species.

(3) Trees which are not felled because of religious sentiments.

The volume (V) of trees in each species was computed using the following general form equations:

i) $\mathbf{V = a + b \times G^2H}$

ii) $\mathbf{V = c + d \times D^2H}$

Where G is girth at breast height, D is diameter, a and c are constants, and b and d are regression co-efficients. By adding up the tree volumes (expressed in m^3) of all species under various land categories, the total growing stock in each of the villages was arrived at.

2.2.2 Shrub

For shrubs, species-wise biomass production was estimated by quadrate study method. Out of, more than fifteen woody shrub species, two i.e. Rhus parviflora (Tungla) and Berberis asiatica (Kingoda) were widely used for fuel purposes. Other species extracted were Hissr (Rubus ellipticus), Bendu (Grewia sclerophylla) and Dhaula (Woodfordia fructicosa).

For shrubs, initially a quadrate of 2.5 m x 2.5 m was laid down and by extending its sides, step by step, by 2.5 m, five quadrates were laid down in each of the six villages. Within quadrates, number of plants for all the species was counted and recorded separately. For each of the plants, number of tillers was counted and height as well as girth at 5 cm above ground was measured for the leading shoot. Later, in every village five plants per species were harvested and weighed first with leaves and then without leaves. Sufficient data was gathered to work out regression equations of the form:

$Y = a + b\ ND^2H$; where,

N - number of tillers

D - diameter (dm)

H - height (dm)

Y - green weight of individual plant without leaves (kg)

Formulae

1. Shrub biomass production per hectare = $\frac{\text{Shrub production in the quadrate}}{\text{Area of the quadrate (sq.m.)}} \times 10{,}000$

2. Total shrub biomass production = Average shrub production per hectare x [Total village common land + Bheeta land (both in hectares)]

It was observed that the reliable equations could be formulated only for Tungla (Rhus parviflora) and Kingoda (Berberis asiatica). Thereafter, a regression equation for shrub biomass irrespective of the species was developed, and it was observed that this equation had a better correlation coefficient and was considered more reliable. The general regression equation used for shrubs is given in Table 2.2.

Table 2.2. Regression equation developed for shrub

Species	n	a	b	r^2	SE_x	SE_y
General	61	-0.098	0.21	0.91	0.009	0.33

Samples were drawn for each species and air-dried for a month and half, then they were oven-dried. It was observed that wood samples lost almost half of their weight i.e., 52.07 per cent. On an average the dry weight was almost 0.47 times the wet weight.

Dry shrub biomass production was calculated by using the following formula:

Total shrub production = Shrub production/ha x Avg. dry to wet wood ratio x Total common land + share as per the land settlement

Total production was never completely extracted so it was assumed that every year only half of the total production was being harvested.

It was observed that shrubs grow under chir (Pinus roxburghii) in village forest land because of relatively open canopy. However, understorey did not exist under the chir dominated government owned forest because of higher canopy density. As shrubs were existing under chir canopy in villages, so village forest land should always be accounted for while calculating shrub production.

2.2.3 Grass

Grass production was estimated by the quadrate study method. It was found that within the village boundary, grasses grew on all community land including wasteland, village forest, depressions, grazing land, etc. besides the Bheeta land.[3]

For Bheeta land, measurements were made for five agricultural fields in a village (Table 2.3). The area for the fields was taken from Patwari records after identifying the fields on village map by field number. Bunds were measured for length and vertical height between two contiguous agricultural fields. Bheeta land associated with the field was determined by the formula:

Bheeta area = Bund length x Height between consequent fields

Depending on the Bheeta area for individual fields, average Bheeta land per hectare was estimated.

Table 2.3. Average Bheeta land per hectare

Field No.	Plot No.	Area (ha)	Bund length (m)	Height between contiguous fields (m)	Bund area (sq.m.)	Bund area per hectare (sq.m.)
1.	2940, 2941, 2945	0.092	104.00	1.5	156.00	1895.65
2.	2967	0.031	51.67	1.3	67.17	2166.77
3.	2977	0.020	44.00	1.0	44.00	2200.00
4.	2953 to 2963	0.126	139.67	3	419.01	3325.48
5.	2942 to 2947	0.073	83.33	2	166.66	2283.01
					Average -	2334.18 ±493.08

Bheeta land - the vertical land in between two contiguous agricultural fields.

To calculate the grass production, 60 quadrates (10 each in six villages) were laid on common lands and grasses were harvested. Data presented in Table 2.4 reveals that within villages, grass production varied from 0.145 to 0.330 gm/sq.m. with standard deviation varying between 0.035 to 0.15. However, for all the quadrates, grass production averaged to 0.229 gm/sq.m. with standard deviation of 0.118. Grass production was never converted to dry matter production because grass was consumed the day it was harvested.

Table 2.4. Average grass production in selected villages (in kg/m^2)

No.	Village Agrora	Avg. production	Stand. deviation
1.	Agrora	0.330	0.129
2.	Toli	0.145	0.035
3.	Nauli	0.308	0.151
4.	Nausin	0.172	0.045
5.	Kadola	0.211	0.076
6.	Ghiri	0.205	0.089
	For 60 quadrates	0.229	0.118

Total grass production in a village was calculated by using the following formula:

$$\text{Grass Production} = \frac{\text{Dry wt. of grass}}{\text{Area of quadrate}} \times [\text{Village common land} + \text{Bheeta land}]$$

2.2.4 Agricultural crop residues

On the basis of the land under different crops, Rice (Oryza sativa), Wheat (Triticum aestium), Mandwa (Eiusine carocona), Jhangora (Opisminus frumentecious) and Barley (Avena sativa), were identified as major agricultural crops. Crop residues were primarily fed to animals but these also supplemented fuelwood.

For *desi* and hybrid varieties in irrigated and un-irrigated conditions, separate quadrates were laid in three villages at various altitudes. A wooden quadrate with all the four sides measuring 0.5 m was randomly placed in the agricultural fields. All the crop in the quadrate was harvested, tied up and left for air drying at a clean, protected place for four days. The grains from the harvested crop were extracted and weighed separately. Residues and grains were again air dried for four days and were re-weighed. The grains were dehusked and these were weighed again separately to get the actual grain-straw ratio (Table 2.8). Total grain production in the village was estimated using the land-use data, and the grain productivity data obtained from Computerized District Database Centre, Pauri.

2.2.5 Dung

The collection efficiency from the field was assumed to be negligible and the dung collected from cattle-shed was the total dung available to a household. The dung produced within 24 hours was weighed, the next morning. This exercise was replicated thrice in a household. The following was used for estimating total dung production in a village:

Total Dung Production = Avg. dung production/day/cattle x Total no. of cattle x 365

To determine the dung production in terms of dry matter, four samples were oven-dried. It was observed that dung-cakes lose almost 3/4th of weight on drying (Table 2.5).

Table 2.5. Drying the dung samples

No.	Initial weight (gm)	Oven drying (gm)				Dry weight/ wet weight
		I	II	III	Final	
1.	150	37.16	32.85	32.41	32.41	0.22
2.	200	66.35	58.74	58.28	58.28	0.29
3.	150	43.09	38.22	37.98	37.98	0.25
4.	150	37.51	32.75	32.53	32.53	0.22
						Average =0.24 ± 0.03

2.3 Study of biomass consumption pattern

The secondary data for the biomass consumption survey was collected from the food and civil supply officer, kerosene and LPG depots, electricity as well as forest department. A detailed primary survey of selected households in every village was conducted with the help of a questionnaire. For a few observations, measurements were made using different instruments, e.g. weighing dung cakes or determining the proportion of shrub and tree biomass in fuel. Besides the primary survey, discussions were held with the village Pradhan, Sarpanch, and also the elders. The questionnaire used for the survey appears in Appendix 6. Various socio-economic aspects were given due consideration and detailed sections were formulated for household details, food and cooking habits, cookstoves, livestock, and consumption of dung-cakes, LPG, kerosene in domestic as well as agriculture sector. Besides these, separate sections were included on collection of various biomass resources and energy crisis (Table 2.6).

Table 2.6. Information asked in the household level questionnaire

No.	Major Head	Information
1.	Household:	Family size, number of Men, Women, Youth, Children, Occupation, Electrification
2.	Food habits and cooking method:	Consumption of various food stuff, duration of cooking, location of kitchen, utensils
3.	Cooking device:	Type, fuel, source of fuel, prefered fuel (species)
4.	Livestock details:	Species, number, type of animal fodder consumption (various sources), end-use of cow-dung

5.	Domestic energy consumption:	Various sources of energy across season, quantity consumed of dung cake, firewood, kerosene for cooking, water heating, etc.
6.	Agricultural energy consumption:	Crop-wise residue production and uses
7.	Collection of biomass (wood, grass):	No. of persons, days, trips, source
8.	Cow-dung consumption:	Manure, dung, plaster, trade
9.	Energy crises:	Scarcity indicators, reasons, options and priorities

In the selected villages, the households were categorized into large, medium and small according to the land ownership i.e. more than 60 nali, 15-60 nali and less than 15 nali of land, respectively. In terms of numbers, at least one fourth of the total families in a village were surveyed after selecting households on a proportional basis. After the survey in December 1991, it was decided that from all the categories a minimum of three families were selected.

Biomass consumption in a few selected households was monitored thrice at an interval of 24 hours. The possibility of measuring the consumption over a long period of 72 hours (3 days) was considered since that might give a better figure for average consumption.

During the first visit, the purpose of the study was explained to the senior houselady (generally wife or mother of the head of family) and was requested to co-operate. The respondent was asked to set aside all the biomass (dung cakes, grass, crop-residues and wood from shrubs as well as trees) that would be required during the following 24 hours, and some extra was added to ensure that there would be no shortfall. The different biomass fuels were then weighed to the nearest 50 gram by a spring balance. After weighing, the fuel was placed in a single pile on the floor of kitchen or at a convenient place. The houselady was requested to use biomass only from that pile. The household was visited thrice after subsequent 24 hours and the biomass remaining in the pile was diaggregated for various biomass to weigh the leftover and assess the amount consumed in last 24 hours. Again a similar heap of various biomass was kept to meet the fuel and fodder demand for next 24 hours.

In hills, most of the houses used wood for doors, windows, supports, racks and roofing material. But a few houses in every village were cemented, and consumed less amount of timber. To calculate the timber consumption, all the wood used for construction was measured. To assess the average timber consumption per household, at least 4 households in every village were enumerated for timber consumption.

The timber consumption was estimated in minimum of four and maximum of fifteen families in a village depending on the total number of families in a village as presented in Table 2.7.

Table 2.7. Number of families selected for estimating timber consumption

Total families	Sample size
1-10	4
10-20	6
20-40	8
40-100	10
> 100	15

The aggregation at the village level was based on the data on human population, cattle population and number of households. Seasonal variations in consumption are also considered.

2.4 Stress analysis

Consumption of various biomass resources was equated against the respective sustainable supply to compute the stress on different biomass resources by using the formula:

$$\text{Stress} = \frac{\text{Total biomass consumption}}{\text{Sustainable biomass supply}}$$

For computing the stress on cowdung production, the dung consumption for dung-cakes and manure was clubbed and equated against total dung production. Both grass and agricultural crop residues, were being fed to the livestock. To compute the stress caused by fodder consumption, only the grasses were considered because the total agricultural crop residues produced in a biomass system was being consumed locally and excess stress for fodder was met with grass supply from outside the biomass system. Therefore, the supply and consumption of agricultural crop residues were assumed to be equal and the stress on agricultural crop residue was always unity.

The stress on the sustainable supply of the biomass caused by the existing consumption pattern was computed for the base year by using the formula. However, the stress might be analyzed in qualitative terms by observing the species being burnt, the canopy density and the type of biomass being used as fuelwood. In an excessively harvested system, people would have consumed the preferred fuel species already, and would have switched over to second grade fuel species. And under severe stress conditions, they might use fodder or timber species. Similarly, the openings in the forest stand would also suggest the intensity of harvesting. Another indicator was to look at the type of biomass being used, because in area with extensive forests people use wood and as the availability of wood declines, people might switch over to shrubs or dung-cakes.

It was observed that 90.2 per cent and 9.8 per cent of fuelwood was contributed by shrub biomass and loppings from trees, respectively (Table 5.10). Total fuelwood consumption was distributed over shrubs and sustainable yield from trees in the above mentioned proportion. The sustainable yield from trees included the yield from scattered trees as well as forest canopies. Though,, the yield from canopies should not be equated against fuelwood consumption as it was the only possible source to meet timber demand. But only one canopy i.e. in village Noselu could yield some timber whereas canopies in other villages were immature and could yield only fuel. Moreover, the timber extraction was not allowed without official permission so the local resources could yield only fuelwood. The stress due to timber requirement was computed only for the villages having forest settlement. The villages for which timber share (sustainable yield) was predictable from secondary sources, the stress was computed by equating the sustainable yield against the timber consumed per year. The annual timber consumption was assumed to be 5 per cent of the total timber already consumed in the village. It means that all the timber consumed would be replaced within next 20 years.

2.5 Biomass development plan

The biomass plan is a complete document detailing the present biomass scenario; covering the potential supply of various biomass resources as well as their consumption pattern, stress on various resources and the strategies to minimize the stress for better management of the natural biomass resources in an environment friendly way. A biomass plan should perceive the impacts of the proposed strategies; identify various infrastructural requirements and assign the specific role to various interacting agencies. At the micro-level, a plan ensures better interaction among various departments, reduces biasness (except political) and provides a better chances of monitoring.

In the most desirable situation, a planner would like to generate local resources to meet the biomass consumption in the target year. Various management strategies are suggested to minimize the stress in the target year for the biomass system to be self-sustainable. Efforts are made to estimate the scope of commercial and non-commercial renewable energy sources, in case the local sustainable supply fails to meet the consumption in the target year.

Various strategies involved in planning may be enlisted as:

1. To increase the productivity of existing stands.
2. To increase the growing stock.
3. To supplement the supplies through PDS and/or RETs (Renewable Energy Technologies), if required.

The biomass plan should integrate resource conservation with the general development of the village. Increased agriculture residue production might replace tree biomass from being used as fodder and encourage timber or fuelwood yield. Moreover, it might enhance the purchasing power and hence provide room for fuel saving devices, based on conventional and non-conventional energy sources.

2.6 Norms used

The information such as, agricultural crop productivity, dry to wet ratios for shrub and dung, required for every village did not change due to homogeneous climatic conditions, and similar plant as well as animal genotype and agronomic practices. Moreover, some of the information could not be gathered for all the villages because of either short harvesting season or only one harvesting season in a year. Owing to these reasons it was essential to either use or develop and use local standards.

Various local standards (norms) used in different calculations have been depicted in Table 2.8.

Table 2.8. Various local norms used in calculations

No.	Norms	Value	Units	Source
1.	***Productivity***			
	a) Irrigated rice	1.059	t/ha	Secondary
	b) Un-irrigated rice	1.059	t/ha	Secondary
	c) Jhangora	1.091	t/ha	Secondary
	d) Mandwa	0.932	t/ha	Secondary
	e) Wheat	0.927	t/ha	Secondary
	f) Barley	0.865	t/ha	Secondary
2.	***Grain to straw ratio (before dehusking)***			
	a) Irrigated rice	1:1.88		Primary
	b) Un-irrigated rice	1:1.83		Primary
	c) Jhangore	1:2.40		Primary
	d) Mandwa	1:2.10		Primary
	e) Wheat	1:1.99		Primary
	f) Barley	1:1.23		Primary
3.	***Grain to straw ratio (after dehusking)***			
	a) Irrigated rice	1:2.27		Primary
	b) Un-irrigated rice	1:2.32		Primary
	c) Jhangore	1:2.35		Primary
	d) Mandwa	1:2.93		Primary
	e) Wheat	1:1.99		Primary
	f) Barley	1:1.23		Primary
4.	***Dry to wet weight ratio***			
	a) Dung	0.24		Primary
	b) Shrub	0.47		Primary
5.	***Productivity***			
	a) Grass	0.228	t/ha	Primary
	b) Shrub	7.092	t/ha	Primary
6.	***Rotation***			
	a) Forest stock within village	50	Year	Assumed
	b) Forest stands	75	Year	Assumed
7.	***Bheeta land ratio***	0.23		Primary

CHAPTER 3
Study area and selection of villages

The Department of Watershed Management (Jalagam), U.P., has identified the boundaries of the Irgad micro-watershed and has given following description:

> On the basis of LANDSAT imagery, U.P. hills were divided into 8 catchments and further subdivided into 28 watersheds, which in turn were divided into 119 sub-watersheds and eventually 1150 micro-watersheds. Irgad micro-watershed (Number 3), a part of West Nayar sub-watershed of Nayar Watershed, has a total area of 6164 hectares.

Irgad micro-watershed extends for 30 km and is situated 5 km from Pauri on Pauri-Kotdwar road in Garhwal Himalayas. Various secondary data sources could not provide an appropriate list of the existing villages in the micro-watershed. A primary survey was conducted to verify the location of various villages and complete the list of 86 villages. During the primary survey, information was gathered for altitude, population, aspect as well as filling the gaps in land related secondary data. The table 3.1 lists the villages in the micro watershed and Map 1 shows their location.

Table 3.1. List of villages in the micro watershed.

Name of Village	NRDMS Code	Altitude of Village (m)	Per Capita Agriculture Area (ha)	Per Capita Forest Land (ha)	Human Population
1. Agrora	6001	1450	0.23	0.33	190
2. Ali	11001	1525	0.09	0.12	140
3. Andriyun	11004	1575	0.12	0.42	47
4. Ayal	11007	1450	0.18	0.00	495
5. Bamdav Dhuli	6021	1450	NA	0.00	
6. Bansai	6025	1400	0	0	0
7. Bangargaon	11016	1635	0.1	0.06	150
8. Bhainsrau	11028	1500	0.23	0.22	10
9. Bhainswara	11029	1500	0	0	0
10. Bhimali malli	11036	1615	0.08	0.08	185
11. Bhimali talli	11037	1550	0.17	0.23	385
12. Bhakand chek	11030	1525	0	0	0
13 Bhimalli chak	11035	1550	2.52	0.5	4
14. Bisht Dhuli	6044	1500	0.17	0.06	150
15. Bunga Dural	6047	1550	0.08	0.00	95
16. Chamkot	11042	1500	0.36	0.43	29
17. Chrindalu	6054	1400	0.11	0.09	130
18. Dang	6060	1470	0.11	0.12	385
19. Dhar Murgaon	11145	1525	0.17	0.00	125
20. Doblya Malla	11057	1700	0.13	0.16	26
21. Doblya Talla	11058	1650	0.22	0.13	127
22. Dolind	11068	1450	0	0	0
23. Dulinda Malla	6077	1225	0.23	0.23	130
24. Dulinda Talla	6076	1175	0.44	0.28	85
25. Dungri	11071	1490	0.2	0.00	490

Table 3.1. List of villages in the micro watershed. (continued..)

26. Dwarkhil	11072	1510	0.22	0.25	105
27. Dyulion	6080	1500	0	0	0
28. Gad ka Murgaon	11074	1400	0.04	0.00	395
29. Gahar	11078	1725	0.2	0.41	512
30. Ghiri	6090	1360	0.11	0.12	230
31. Gurindi	10052	1410	0.23	0.00	275
32. Jairaj	11097	1540	0.1	0.05	100
33. Jakh	6103	1615	0.11	0.11	125
34. Jakheti	6104	1390	0.07	0.02	138
35. Jaspur	6107	1740	0.38	0.35	95
36. Joshiyana	11101	1400		0.00	130
37. Kadola	6110	1365	0.06	0.08	250
38. Kamera	11107	1540	0.04	0.03	279
39. Kandai	6118	1740	0.25	55.69	65
40. Kadoli	11104	1500	0	0	0
41. Kandai malli	11109	1610	0.08	0.15	380
42. Kandai talli	11110	1585	0.06	0.36	355
43. Kandara	11112	1525	0.09	0.02	333
44. Kaphol gaon	11115	1775	0.07	0.08	150
45. Kaphola Bunga	6048	1545	0.26	0.03	130
46. Kewars	11117	1700	0.05	0.20	805
47. Kandwara	6125	1500	0	0	0
48. Kolri	6133	1615	0.06	0.14	265
49. Kathur	6122	1550	0.47	0.18	191
50. Marora	6160	1425	0.34	0.60	150
51. Majayara	11140	1450	0	0	0
52. Mason	11147	1475	0.12	0.09	382
53. Molti	11154	1450	0.059	0.00	385
54. Nakot	11157	1500	0	0	0
55. Nauli	6179	1515	0.13	0.05	292
56. Narriya	11160	1550	0	0	0
57. Nauriyal Gaon	6171	1440	0.11	0.05	125
58. Nausin	6181	1400	0.17	0.52	90
59. Naugaon	6174	1100	.329	.33	158
60. Nilara	6186	1200		0.60	135

Table 3.1. List of villages in the micro watershed. (continued..)

61. Nisni	11167	1600	0.08	0.16	1289
62. Noselu	11163	1525	0.1	0.20	115
63. Padidul	11173	1440	0.15	0.09	505
64. Palsain	11176	1550	0.11	0.20	180
65. Paligaon	11175	1470	0.06	0.00	110
66. Payasu	6200	1575	0.32	0.04	125
67. Pipli	6202	1350	0.1	0.02	160
68. Pali	-	1600	0	0	0
69. Queed	6128	1540	0.4	0.23	60
70. Rachhuli	11183	1500	0.12	0.11	461
71. Raidul	11184	1585	0.08	0.04	520
72. Rithai	11191	1510	0.05	0.07	184
73. Saknyanatalla	6228	1475	0.13	0.03	125
74. Saknyanamalla	6227	1500	0.21	0.12	125
75. Satmuk	11192	1500	0.02	0.05	90
76. Saulgarh	11193	1450	0	0	0
77. Simtoli	10143	1625	0.08	0.10	448
78. Srikot(partly)	10146	1700	0	0	0
79. Surari	11201	1650	0.16	0.84	21
80. Suraj Dhulli	6246	1580	0.9	0.40	11
81. Teuthya	11207	1540	0.13	0.05	118
82. Thapli	6259	1565	0.17	0.10	625
83. Thaplue	6262	1400	0.07	0.00	0.00
84. Toli	6264	1340	0.15	0.04	325
85. Tunder	11208	1450	0	0	0
86. Uregi	11213	1600	0.12	0.00	805

ollowing parameters were identified for village selection.

(1) Altitude
(2) Per capita forest land
(3) Per capita agriculture land
(4) Human population
(5) Either side of Irgad rivulet
(6) Aspect

On the basis of the primary survey and the secondary information rovided by theComputerized District Database Centre, Pauri Garhwal, ll the villages were categorized in different classes ranging from mini-num to maximum of the characteristics stated above. The summary of he information (Table 3.1) shows that most of the villages were situated etween middle and higher reaches of the micro-watershed. Human opulation did not exceed 500 in most of the villages. It was also ob-erved that for land use data most of the villages had low per capita gricultural land (i.e., less than 0.4 ha) as well as per capita forest land less than 0.3 ha). From the classes representing most of the study area, 5 representative villages were selected (Table 3.2) .

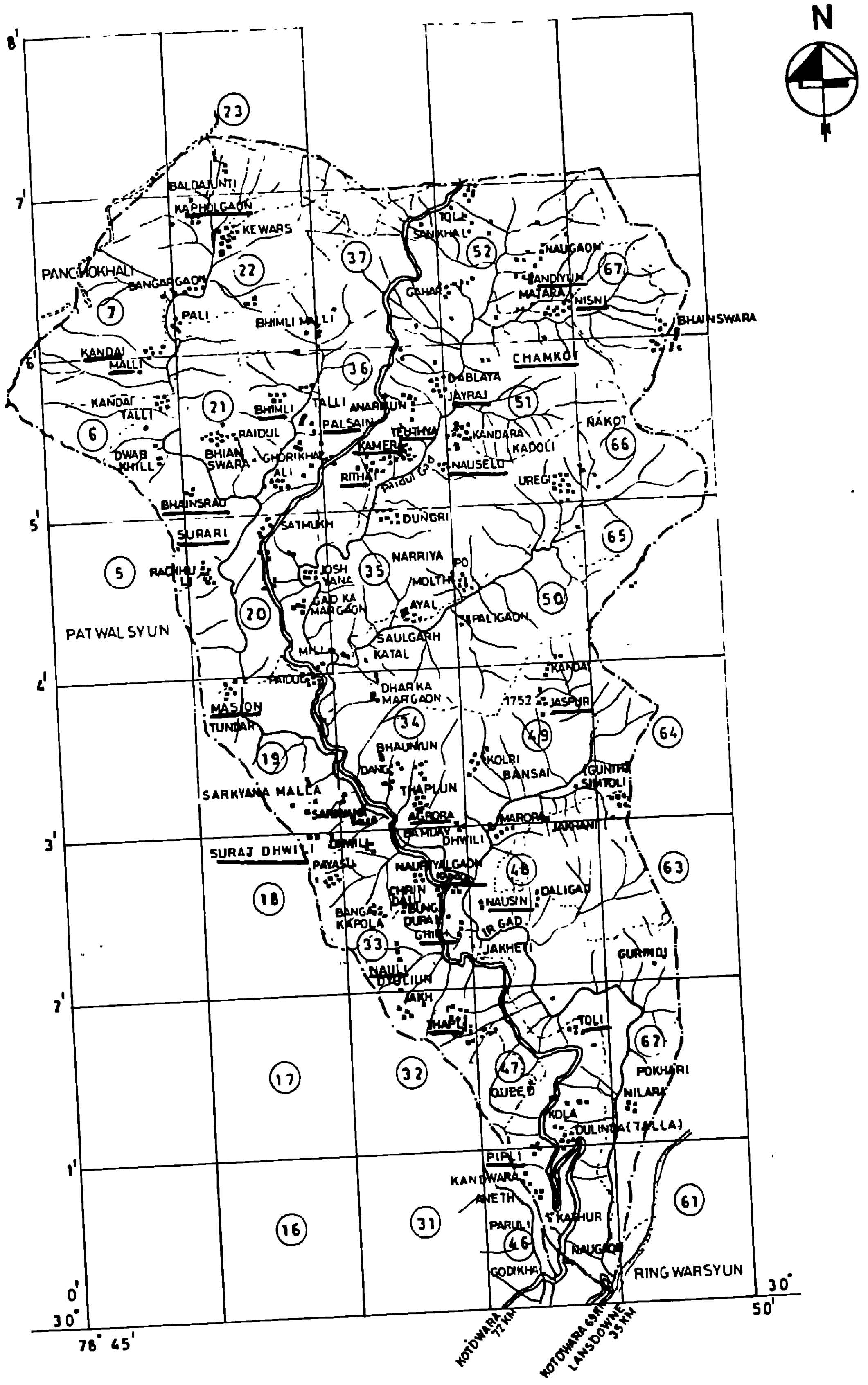
able 3.2. Summary of information collected on various selection criteria

.No.	Criteria	Low	Medium	High	Data Missing
.	Altitude (m)	1175-1375	1375-1575	1575-1775	
	No. of villages	7	59	20	
.	Population	0-500	500-1000	1000-1500	
	No. of villages	79	6	1	
.	Per capita agri. land	0-0.4	0.4-0.8	0.8-1.2]	
	No. of villages	81	3	1	1
.	Per capita forest land	0-0.3	0.3-0.6	0.6-0.9	
	No. of villages	69	13	3	1

Forty villages had common characteristics for all the parameters. These were again classified in eight lists, one each for different aspects i.e. North, South, East and West in both the groups i.e. on both sides of the Irgad water stream. Eleven villages were selected from each of the 'groups' by random selection method. Three more villages were selected only on the basis of human population, one from high (Nisni) and other two from low size human population (Suraj dhulli and Surari). The final list of selected villages and some basic information on them is given in Table 3.3.

Table 3.3. Secondary information on selected villages in Irgad micro-watershed

Village	Total area (ha)	Total population	Total families	Forest land (ha)	Cult. waste + grassland (ha)	Irrigated land (ha)	Un-irri. land (ha)	Altitude		
								MINI. (m)	MAX.M (m)	AVG. (m)
CHAMKOT	23.47	29	5	1.21	11.33		10.21	1500	1500	1500
ANDRIYUN	18.21	47	12	7.69	4.45		5.67	1550	1600	1575
NAUSIN	64.35	58	12	22.66	25.9		12.95	1400	1400	1400
JASPUR	91.46	94	18	2.83	25.09	0.81	52.21	1730	1750	1740
JAIRAJ	19.43	100	26	2.43	0.41		13.76	1530	1550	1540
BHAINSARU	41.68	98	24	5 26	7.69		26.3	1500	1520	1510
NOSELU	35.61	115	26	17.4	1.21		14.97	1520	1530	1525
TIOTIYA	21.45	118	29		8.09		12.55	1530	1550	1540
THAPLI	173.39	620	126	29.11	32.98		68.53	1550	1575	1565
SURAJ DHULLI	18.5	11	1	4.1	4.56	0	5.2	1580	1580	1580
KAPHOLGAON	23.88	165	35	0.81	10.12	0 4	11.74	1700	1850	1775
PIPLI	20.64	46	8	5 67			14.16	1350	1350	1350
PALSAIN	60.71	174	34	33.59			24.69	1500	1550	1525
RITHAI	22.26	184	43	4.05	6.07	0 4	8.5	1500	1520	1510
BHIMALLI MALLI	29.95	171	40	6.07	2.03		14.97	1590	1640	1615
AGRORA	106.03	227	47	4.45	23.88	1.21	31.16	1400	1500	1450
GHIRI	54 23	202	45	2.44	27.92	8.5	103.6	1350	1370	1360
KADOLA	34.8	69	13	2	4		26	1350	1380	1365
KAMERA	23.47	279	52	3.24	6 88	0 4	10.52	1540	1540	1540
NAULI	61.11	269	NA		17.81		38.04	1480	1550	1515
TOLI	76.08	185	40	7 02	10.93	11.74	32.38	1320	1360	1340
KANDAI MALLI	89.84	289	75	40 47	21.45	2.83	24.28	1590	1630	1610
MASON	118.17	382	102	10 51	38.4	11.73	51.41	1450	1500	1475
SURARI	22 26	21	3	0	13.91	0	5.6	1650	1650	1650
NISNI	327	1289	257	176.85	22 26		108.05	1650	1750	1700



PAURI — IR GAD C.O.E

LOCATION MAP — (SCALE: 1:50000)

NO. 53 $\frac{J}{16}$ FIRST EDITION

DESCRIPTION	SYMBOL
BOUNDARY	-·-·-
RIVERS/NALAS	~
ROAD	═
HABITATION	∴

The selected vilages are underlined

CHAPTER 4
Progress of work

4.1 Status of fieldwork

In the study, data has been collected on both the aspects i.e., supply of various biomass resources and their consumption in 18 villages out of 25 selected villages in the Irgad micro-watershed. A team camped in the study area for about eight months and collected the data. It took about 22 days to survey a village. In every village the first phase was to collect the secondary data (Goshwara, Khasra and maps from Patwari) and concurrently the household survey was conducted to study the consumption pattern along with the monitoring of dung production. Later on a detailed survey for tree biomass was done. Total present human population was recorded from the village Pradhan's records and cross-checked with various families during the survey. Also various secondary data sources (at Government Departments) were studied. Required data was provided by the Computerised District Database Centre (Pauri) after seeking an approval from the local District Magistrate. The divisions dealing with census, Van-panchayat and revenue records were very co-operative. Though one had to make efforts to trace the relevant age-old documents but the concerned officers never refused to share the information. Discussions were held with various divisions of Forest department, the proposed study and all the required information was obtained about Reserve Forests.

4.1.1 Households sampled

In a selected village the households were categorized as per the land owned i.e. more than 60 nali, 15-60 nali, and less than 15 nali of land. A total of one fourth of the total families belonging to different categories was selected on a proportional basis. However, in the small villages the sample size was increased (Table 4.1).

Table 4.1. Sample size of households surveyed in various villages.

No.	Village Code	Village Name	Total No. of House-holds	Agricultural land (nali)			Sample Size	Sample Size
				0-15	15-60	> 60	(No.)	(%)
1.	06001	Agrora	48	2	10	2	14	29.2
2.	06090	Ghiri	40	-	13	1	14	35.0
3.	06110	Kadola	15	2	4	-	6	40.0
4.	06107	Jaspur	32	-	13	-	13	40.6
5.	11042	Chamkot	8	-	4	-	4	50.0
6.	06264	Toli	51	1	15	1	17	33.3
7.	06259	Thapli	130	2	30	1	33	25.3
8.	11207	Teuthiya	15	-	9	-	9	60.0
9.	11004	Andriyon	8	-	6	-	6	75.0
10.	11163	Noselu	24	-	12	-	12	50.0
11.	6181	Nausin	7	-	3	-	3	42.9
12.	6179	Nauli	55	10	10	-	20	36.4
13.	6202	Pipli	12	-	12	-	10	83.3
14.	11201	Surari	2	-	2	-	2	100
15.	11097	Jairaj	27	6	7	-	13	48.1
16.	11191	Rithai	41	7	9	3	19	46.3
17.	11107	Kamera	55	8	13	-	21	38.2
18.		Suraj Dhulli	2	-	-	2	2	100

Detailed information gathered from revenue records for the land owned by various households was re-confirmed by the village Pardhan and the elders of the village to select the sample (no. of households).

4.2 Software Development

4.2.1 Scope

The aim has been to develop a user friendly decision support system for planning at the micro level. This is seen as an exercise, that would be useful in developing a biomass management plan for a village or a biomass system. The software converts the data on different biomass sources, using the methodology discussed in earlier chapters, into relevant information about the availability and consumption of these, which would aid decision makers in planning and managing the biomass resources of a village.

The software is menu driven, interactive and presents information in a tabular form on yearly production of dung, crop residues, grasses, shrubs and woody biomass from trees, and also gives consumption of these sources for energy and non-energy uses at the village level. Furthermore, it enables users to specify alternatives and carry out a sensitivity analysis to observe how these would influence the biomass supply by identifying conditions under which the stress on biomass resources is minimum.

The classification and storage of data required, structure of the model and the use of software are described in the following sections.

4.2.2 Database structure

Data required for a village can be broadly classified into:

- variables for estimating supply and
- variables for estimating consumption

The supply side variables are at village level, and are divided into information on land use, demography and trees whereas for consumption, these are at household level and are divided into seasonal consumption of fuel, fodder and timber. The table 4.3 gives the detailed classification of data and its sources.

Table 4.2. Classification of the required data

Class	Source
A. Supply	
1. Demography	Primary survey
- Human Used for estimating consumption.	
- Livestock Used for estimating dung production.	
2. Land	
- Land use under different crops Area under major kharif crops - rice (irrigated and unirrigated), jhangora, mandwa and rabi crops - wheat, barley. Used for estimating the total crop residue availability in the village.	Goshwara (Patwari)
- Land use as per revenue records Land under grazing, barren, agriculture fallow, depressions and village forest. Used for estimating grass and shrub production from common land.	Khasra(Patwari)
- Land settlement records Accords of concessions for harvesting shrubs and/or grasses from government forest and on revenue land. Used for estimating share of grass and shrub production from settlement lands.	Revenue and Forest department (Reserve)
- Agriculture land ownership of others and elsewhere Used to account for export/import of crop residues in a village.	Khasra (Patwari)

Continued...

Class	Source
3. Trees	
- Canopy Area under the canopy of trees, dominant tree specie, crop height and basal area of the canopy, from at the most ten different locations. Used for estimating the availability of woody biomass from a canopy.	Primary survey
- Scattered Girth at Breast Height (GBH) and height for all trees of various species on homestead, agriculture and common land. Used for estimating woody biomass from single trees.	Primary survey
B. Consumption (household level)	Primary survey
1. Fuel	
- Fuelwood Seasonal daily consumption for heating and cooking.	Primary survey
- Dungcake Seasonal daily consumption for heating, cooking and manure.	Primary survey
- Kerosene Seasonal monthly consumption for cooking and lighting.	Primary survey
• Electricity consumption	Primary survey
2. Fodder	Primary survey
Seasonal monthly consumption of crop residue and grasses.	
3. Timber	Primary survey

Various aspects of biomass supply and consumption have been classified as modules in the software, which interact as shown in the flow chart discussed.

Boxes B and C correspond to estimation of biomass consumption and availability in the baseline year, respectively. The output from this stage would be used in box D where the stress for the baseline year will be computed. The user could then specify the target year for which the stress was to be forecasted. Boxes E and F will then predict the demand and supply of biomass in that year using data from boxes B and C, respectively. Stress in the target year would be computed in the same manner as in box D.

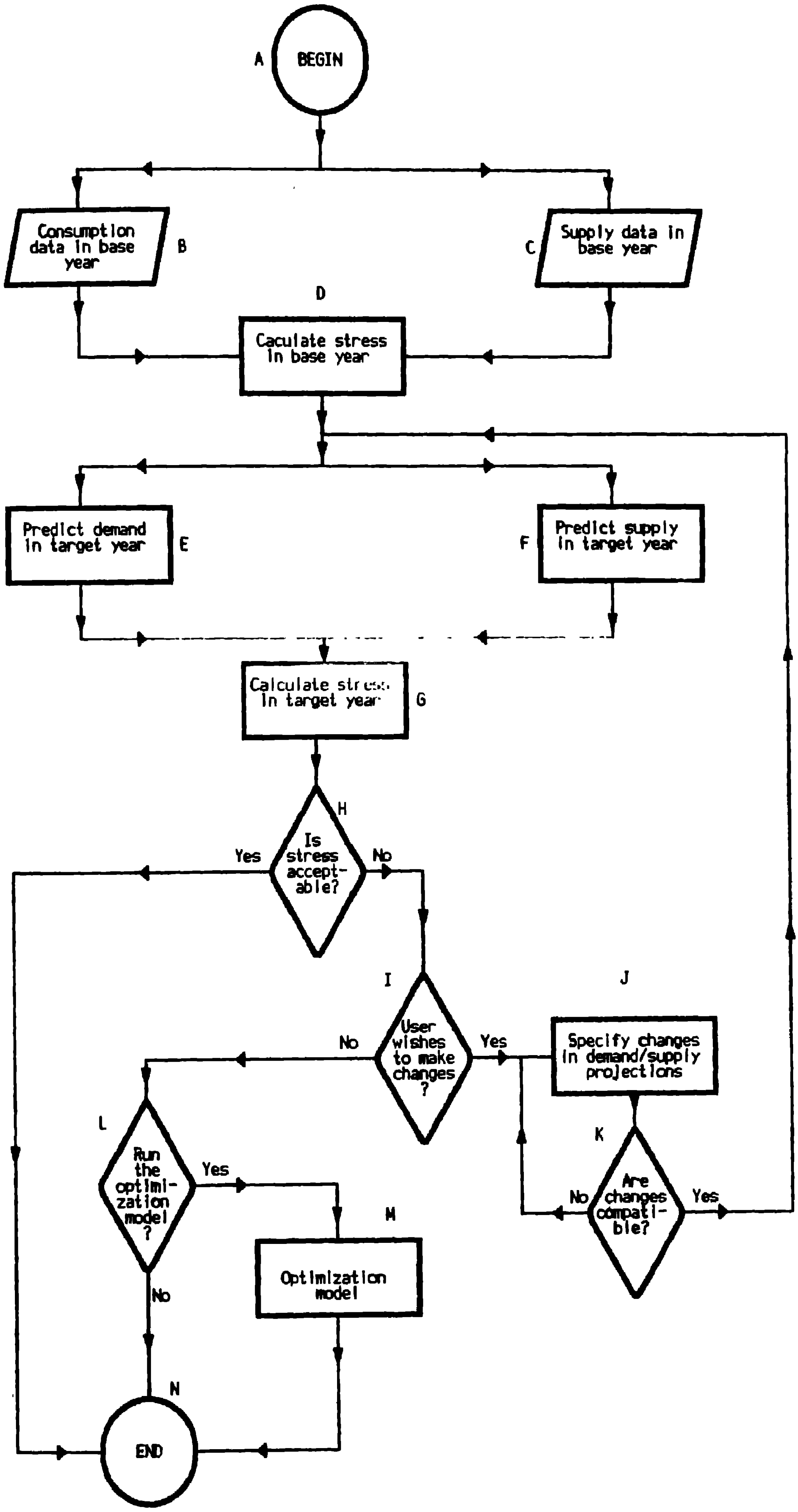
If the stress is found to be within acceptable limits, the exercise ends. Otherwise, the user has the option to specify either some alternative scenarios for growth (box J) or use the in-built optimization module (box M). This module would essentially involve linear goal programming.

In the alternate scenarios the user would be able to specify changes in factors such as population growth rate, fuel-mix, and plans for forestry, irrigation projects. Before analyzing the alternate scenarios (box J) the software would check with a truth table if the alterations are acceptable. A similar truth table would be a part of the optimization module.

4.2.3 Database design

Data on related information is stored in a database for easy storage, retrieval or access. In a database file, all the data for a particular entry are called a record and each item of information within a record is called a field. For this exercise, data is stored in dbase III+ files where fields represent variables and records correspond to lowest unit for which the variables exist. The lowest unit may be a village or a canopy or a piece of agricultural land or a household. The variables are divided into three types:

- input from the user (village specific)
- computed by the software (village specific)
- local standards (available or developed for the study area)


A
BEGIN
Consumption data in base year
B
C
Supply data in base year
D
Caculate stress in base year
Predict demand in target year
E
F
Predict supply in target year
Calculate stress in target year
G
H
Is stress accept-able?
Yes
No
I
User wishes to make changes ?
No
Yes
J
Specify changes in demand/supply projections
K
Are changes compati-ble?
No
Yes
L
Run the optimi-zation model ?
Yes
No
M
Optimization model
N
END

FLOWCHART FOR THE SOFTWARE

The first two types are organized into different files based on the levels (lowest units) and the classification given in Table 4.3. The third type i.e. standards are stored in two files, one for supply and another for consumption.

Different levels of data storage and the related DBF files are given in Table 4.3.

Table 4.3. Data organization in DBF files

Aspect	Level	File	Contents
Supply	Village	VILLAGE.DBF	Demographic and land use information as per revenue records.
		SUPPLY.DBF	Land under different crops in a village, total govt. forest land along with share of grasses and shrubs available to a village from it.
	Land	AR_AGRI.DBF	Information restricted to those agricultural lands which are physically located in a particular village but whose beneficiaries reside in other villages.
	Canopy	AR_CANOP.DBF	Land settlement accords on village, private or department forests/canopies.
		CANOPY.DBF	Information required to estimate the volume of woody biomass of tree canopies.

Continued...

Aspect	Level	File	Contents
	Tree	TREE.DBF	Information required to estimate the volume of woody biomass of scattered trees.
		TR_INV.DBF	Regression constants existing for different tree species.
	Study area	SUP_CON.DBF	Standards developed for supply estimation.
Consumption	Household	CONSUMP.DBF	Data on seasonal household consumption of fuel, fodder and timber.
	Study area	CONS_CON.DBF	Standards developed for consumption estimation.

For a given village, data is extracted from these files and is aggregated to village level wherever required. The linkages among these files are provided by codified key fields like village, canopy and tree species as shown in Figure 4.1.

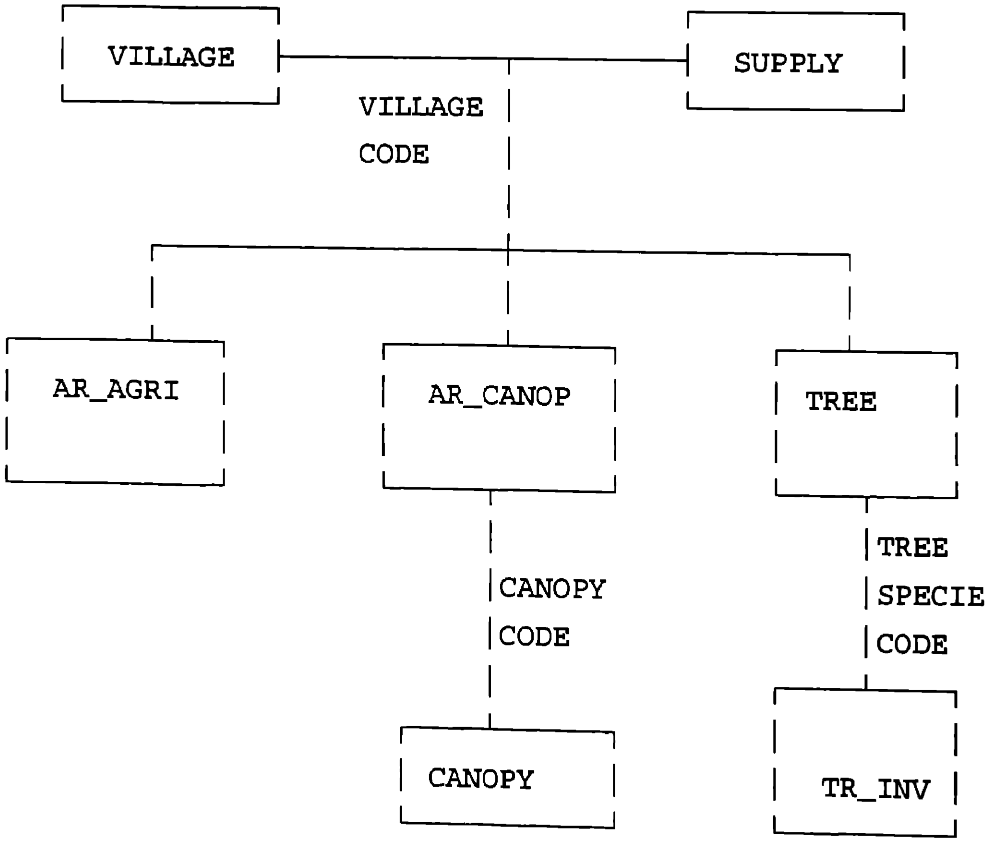


Figure 4.1 Linkages within various files

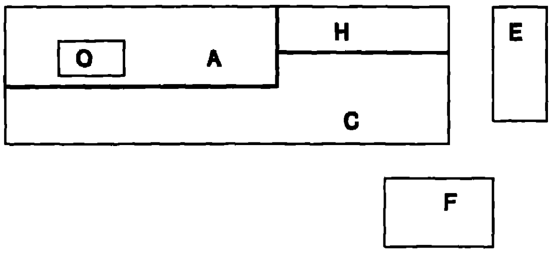
4.2.4 Model structure

Basic unit

The basic unit of analysis is a biomass system which may be a self-sufficient village i.e. no export/import/sharing of biomass resources or a village harvesting different biomass sources which fall outside the village boundary, like agriculture land owned elsewhere or rights on government forest land.

The schematic map of village is depicted in figure 4.2.

Figure 4.2. General schematic map of a village



where

A = total agricultural land
O = agricultural land owned by other villagers
E = agricultural land owned elsewhere by this village
H = Area under homesteads
C = Common lands and wastelands
F = Govt. forest on which the village has rights (Proportional sustainable volume is added)
T = Total land within village boundary
= A+C+H
T'= Total land available for biomass extraction to the village
= A-O+E+H+C+F

4.2.5 Future plans

Data entry module

Interactive data entry screens on the lines of classification given in Table 4.3 will be designed. These will have data consistency checks such as agriculture land is less than total land, and agriculture area owned by others is less than or equal to total agriculture land. The errors will be reported to the user and if not rectified, will be reflected in the results.

Forecasting module

Two types of forecasting are envisaged - the no intervention,business-as-usual forecasting and normative forecasting. In case of first one, the user is given the option of to either specify growth/depletion rates or to directly input the absolute values of the variables for the target year. If the growth rates are specified, a variable transformation module will create records for the target year. The consumption is then forecasted using equations predicted by multiple regression analysis. To generate these regression equations, we need consumption and supply estimates for base year for at least 25 villages, to have some statistical confidence in the constants.

For the normative forecasting we need information on what are ideal or recommended values for energy per head, fodder feed per livestock, manure requirements per hectare of crop, etc.

For both types of forecasting, it is recommended that first consumption is to be estimated and then compared with sustainable limits for each fuel type.

4.3 Status of analysis

Table 4.4. Details of the information gathered on biomass supply for various villages

No.	Information	(No. of Villages) Collected	Analysed Keyed In	(Yes/No)
1.	Human population	18	18	
2.	Livestock population	18	18	
3.	Collection of various secondary information	18	18	
4.	Bheeta land *	1	1	Yes
5.	Grass productivity *	6	6	Yes
6.	Shrub productivity *	6	6	Yes
7.	Tree statistics			
	a) Scattered	18	18	Yes (10)
	b) Canopy	8	8	Yes (4)
8.	Grain to straw ratio (5 crops) *	3	3	Yes
9.	Dry to wet ratio (Dung) *	1	1	Yes
10.	Dry to wet ratio (Shrub) *	6	6	Yes
11.	Dung production/day/cattle *	18	18	No
12.	Dung use for cakes *	18	18	No

* To be developed as standard at watershed level

Some of the information listed in Table 4.4 has to be analyzed and developed as standard at watershed level. The ratio of Bheeta land to agricultural land and ratio of dry to wet weight of dung were determined only once. Grain to straw ratio was determined for various crops in three villages representing different altitudes. Though paddy and wheat were irrigated, but sufficient replication of irrigated wheat fields were not available in the selected villages so its grain to straw ratio was not estimated. Quadrates were laid in six villages to determine grass as well as shrub productivity (results detailed in Chapter 5). The observations of basal area and crop height were taken in forest stands of eight villages as only these villages had forest canopies out of the 18 villages surveyed, so far. For the villages having rights on Reserve Forest, the annual timber supply was mentioned in appropriate records available with the forest department and Van Panchayat Inspector. The timber right approved for the selected villages had been detailed in Table 4.5.

Table 4.5. Timber rights approved for the selected villages

No.	Village	Timber Yield (Tonne)	Forest (Name)
1.	Kandara	2.76	Sigad
2.	Nauselu	0.92	Sigad
3.	Tiethiya	1.029	Sigad
4.	Chamkot	2.39	Sigad
5.	Andriyon	0.43	Sigad

The details of information on biomass consumption gathered from various villages have been provided in Table 4.6 .

Table 4.6. Information gathered on biomass consumption in various villages.

No.	Consumption	No. of Villages collected	Key in	Analysed
1.	Wood - shrubs - trees	18	18	10
2.	Dungcake	18	18	10
3.	Fodder - Agri. crop res. - Grass	18	18	10
4.	Timber	18	18	10
5.	Kerosene	18	18	10
6.	LPG	18	18	10

The questionnaire was pre-tested in village Agrora, and local staff was trained to conduct the consumption survey. So far 18 out of 25 selected villages have been surveyed of the consumption of various biomass resources. However, the information gathered for 10 villages had been analysed. The analysis of data from remaining eight villages is in progress and the survey for the seven villages will be completed by August 1993.

4.4 Plan for July 1993 - March 1994

The outcome of the project is to develop biomass management plans and to prepare a decision support software. The significance of the outputs increased by communicating with the relevant agencies and authorities involved in micro-level planning. Biomass plans prepared for the selected villages will be discussed with the villagers, Panchayat and Van-Panchayats whereas the software may be a matter of interest for the district or divisional level authorities who generally find it difficult to perceive the biomass scenario at village level because of the lack of the relevant data as well as its accurate analysis.

Considering the different nature of the target groups, separate training programmes for the government authorities and various village level authorities. A meeting will be held in Nov. 1993 with district authorities and officials of various computer centres to introduce the software as well as project activities. This is being organised to seek their views to improve upon the software to make it more efficient. The second meeting will be to train the district authorities so that they may incorporate the services of the software while making decisions at the micro level. A biomass plan is essentially linked with the overall development. None of the micro-level planning excercises in rural areas will yield fruits without paying adequate attention to the biomass planning, natural resource development and biomass consumption in an environment friendly way. Similarly, a biomass plan looses applicability if it aims at natural resource conservation without caring for the overall development of the village and a rise in living standards.

It has been planned to conduct meetings with groups of five villages each at a common place and discuss their biomass plans. The data analysis for 10 villages is complete and plans for two villages are also ready. It has been scheduled that after the first meeting with district planners, village level meetings shall start in July 1993 and at the rate of one meeting per month all the selected villages will be covered by November 1993.

Table 4.7. Workplan for the III year

No.	Month & Year	Activity
1/	June, 1993	Interim report, primary survey
2/	July, 1993	Develop data entry module, primary survey, meeting with villagers, plan preparation
3/	Aug., 1993	Forecasting, data analysis, meeting with villagers, plan preparation
4/	Sep., 1993	Data runs, meeting with villagers, plan preparation
5/	Oct., 1993	Data runs, meeting with villagers
6/	Nov., 1993	Meeting with district authorities
7/	Dec., 1993 - March, 1994	Compilation software manual and final report

CHAPTER 5

Results and discussion

In selected villages, various biomass resources i.e., cowdung, shrub, grasses, trees and crop residues were enumerated for potential sustainable annual supply to match local energy requirements. Only one non-energy enduse of biomass i.e. timber consumption was also estimated. This chapter deals with the identification of various biomass systems and the calculation of stress on its natural biomass resources for various end-uses.

5.1 Biomass systems in different villages

The biomass system in selected villages was identified as per the methodology adopted (discussed in Chapter 2). The calculations for biomass systems surveyed villages are provided here.

Biomass System = Village land + Volume as per the settlement (forest & revenue) + Agricultural land elsewhere - Agricultural land owned by outsiders

The following calculations provide information like village name, village code and land records (i.e. total village area and agricultural land owned). Biomass system excluded the area under a common property resource being harvested by a particular village, because the area was neither defined nor demarcated. However, the proportionate share of various biomass harvested from such land was computed and added to respective supplies.

5.1.1 Village Name - Agrora Village Code - 06001

a) Village land 102.12 ha
b) Forest settlement Nil
c) Revenue settlement Nil
d) Agriculture land owned elsewhere

S.No.	Village	Area (ha)	Beneficiary*
1.	Thaplun	2.595	1
2.	Naudiyalgaon	0.286	1
3.	Dang	1.835	1
4.	Sarkyana Valla	0.906	0

* 1 - Harvested by the village (Agrora)
0 - Harvested by outsiders

e) Agriculture land owned by outsiders

S.No.	Village	Area (ha)	Beneficiary**
1.	Ayal	0.40	1
2.	Dang	1.645	0
3.	Kolri	6.35	0

** 1 - Harvested by the village (Agrora)
0 - Harvested by outsiders

Biosystem = 102.12+[2.595+0.286+1.835+0.4]-[0.906+1.645+6.35]
= 102.12 + 5.116 -8.901
= 98.335 ha

5.1.2 Village Name - Ghiri Village Code - 6090

a) Village land 53.96
b) Forest settlement Nil
c) Revenue settlement Nil
d) Agriculture land owned elsewhere

S.No.	Village	Area (ha)	Beneficiary*
1.	Kadola	1.436	1
2.	Nauli	1.133	1

* 1 - Harvested by the village (Ghiri)
0 - Harvested by outsiders

e) Agriculture land owned by outsiders

S.No.	Village	Area (ha)	Beneficiary**
1.	Chindalu	0.011	0

** 1 - Harvested by the village (Ghiri)
0 - Harvested by outsiders

Biosystem = 53.96 + [1.436+1.133] - [0.011]
= 56.518 ha

5.1.3 Village Name - Kadola Village Code - 06110

a)	Village land	35.803 ha
b)	Forest settlement	Nil
c)	Revenue settlement	Nil
d)	Agriculture land owned elsewhere	Nil
e)	Agriculture land owned by outsiders	

S.No.	Village	Area (ha)	Beneficiary**
1.	Ghiri	1.437	0

** 1 - Harvested by the village (Agrora)
0 - Harvested by outsiders

Biosystem = 35.803 - 1.437
= 34.366 ha

5.1.4 Village Name - Jaspur Village Code - 06107

a)	Village land	56.829 ha
b)	Forest settlement	Nil
c)	Revenue settlement	Nil
d)	Agriculture land owned elsewhere	Nil
e)	Agriculture land owned by outsiders	Nil

Biosystem = 56.829 ha

5.1.5 Village Name - Chamkot Village Code - 11042

a)	Village land	30.511 ha
b)	Forest settlement	With Sigad Forest

	Proportion (Percent)	Area (ha)	Honoured
Grass	0.174	682.4	1
Shrub	0.174	50.7***	1

*** Forest area for shrub production = Total forest area - Area under Chir stands

2. Proportionate share (volume) to be computed and added while calculating biomass supply.

c)	Revenue settlement	Nil
d)	Agriculture land owned elsewhere	Nil
e)	Agriculture land owned by outsiders	

S.No.	Village	Area (ha)	Beneficiary**
1.	Mallirai	0.378	1
2.	Dobalya Talla	0.76	0
3.	Gahar	2.473	0
4.	Kandara	4.665	0
5.	Nisni	0.658	0

** 1 - Harvested by the village (Chamkot)
0 - Harvested by outsiders

Biosystem = 30.511 + 0.378 - [0.76+2.473+4.665+0.658]
= 22.333 ha[1]

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[1] The village harvesting the biomass from a land was the beneficiary. All the area for which the beneficiary was the village (marked '1') had to be added to village land and all other (marked '0') had to be deleted to define the biomass system.

5.1.6 Village Name - Thapli Village Code - 06259

a)	Village land	173.62 ha
b)	Forest settlement	Nil
c)	Revenue settlement	

i) With Jwalpa

	Proportion	Area	Honoured
Grass	N.A.		1
Shrub	N.A.		1

ii) With Jhaketi

	Proportion	Area	Honoured
Grass	1	3.08	1
Shrub	1	3.08	1

d) Agriculture land owned elsewhere

S.No.	Village	Area (ha)	Beneficiary*
1.	Jhaketi	10.18	1
2.	Nauli	0.46	1
3.	Nausin	3.496	0
4.	Dhylun	6.669	1

* 1 - Harvested by the village (Thapli)
0 - Harvested by outsiders

e) Agriculture land owned by outsiders

S.No.	Village	Area (ha)	Beneficiary**
1.	Toli	1.388	0

** 1 - Harvested by the village (Thapli)
0 - Harvested by outsiders

Biosystem = 173.62+10.18+0.46+6.669-[3.496+1.388]
= 186.045 ha

Village Thapli had a control over all the resources growing in unhabitated village Jhaketi which had 3.08 ha of common land from where grasses and shrubs were harvested. This was considered an unopposed agreement to harvest the biomass that allowed the whole share to be harvested by village Thapli. As per the sharing of common property resource under revenue settlement, the land would not be added but the share (of total biomass generated) should be added to the potential biomass supply.

5.1.7 Village Name - Toli Village Code - 06264

a)	Village land	61.685 ha
b)	Forest settlement	Nil
c)	Revenue settlement	With Thapli (not honoured)
d)	Agriculture land owned elsewhere	

S.No.	Village	Area (ha)	Beneficiary*
1.	Marora	0.23	1
2.	Thapli	1.388	1

* 1 - Harvested by the village (Toli)
0 - Harvested by outsiders

e) Agriculture land owned by outsiders - Nil

Biosystem = 61.685 + 0.23 + 1.388 = 63.303 ha

5.1.8 Village Name - Teuthiya Village Code - 11207

a)	Village land	21.709 ha
b)	Forest settlement	With Sigad Forest

	Proportion (Percent)	Area (ha)	Honoured
Grass	1.009	682.4	1
Shrub	1.009	50.7	1

c) Revenue settlement Nil

d) Agriculture land owned elsewhere

S.No.	Village	Area (ha)	Beneficiary*
1.	Andriyon	0.652	1
2.	Jairaj	0.25	1
3.	Kamera	0.822	1
4.	Kandara	0.073	1
5.	Noselu	0.129	1

* 1 - Harvested by the village (Teuthiya)
0 - Harvested by outsiders

e) Agriculture land owned by outsiders

S.No.	Village	Area (ha)	Beneficiary**
1.	Dobalya Malla	1.546	0
2.	Dobalya Talla	0.13	0
3.	Dungri	0.112	0
4.	Dwarkhil	0.2	1
5.	Jairaj	0.423	0
6.	Kamera	2.753	0
7.	Kandara	2.332	0
8.	Nakot	0.826	1
9.	Noselu	0.059	0
10.	Nisni	0.853	0
11.	Rithai	0.894	0

** 1 - Harvested by the village (Teuthiya)
0 - Harvested by outsiders

Biosystem = 21.709 + [0.652+0.25+0.822+0.073+0.129+0.2+0.826] - [1.546+0.13+0.112+0.423+2.753+2.332+0.059+0.853+0-.894]
= 15.559 ha

5.1.9 Village Name - Andriyon Village Code - 11004

a)	Village land	18.243 ha
b)	Forest settlement	With Sigad

	Proportion (Percent)	Area (ha)	Honoured
Grass	0.417	682.4	1
Shrub	0.417	50.7	1

c)	Revenue settlement	Nil
d)	Agriculture land owned elsewhere	

S.No.	Village	Area (ha)	Beneficiary*
1.	Dobalya Malla	0.816	1
2.	Jairaj	0.581	1
3.	Kamera	0.528	1
4.	Kandara	0.631	1

* 1 - Harvested by the village (Andriyon)
0 - Harvested by outsiders

e) Agriculture land owned by outsiders

S.No.	Village	Area (ha)	Beneficiary**
1.	Doblya Malla	0.35	0
2.	Doblya Talla	0.444	0
3.	Kamera	1.115	0
4.	Nakot	0.293	1
5.	Teuthiya	0.653	0

** 1 - Harvested by the village (Andriyon)
0 - Harvested by outsiders

Biosystem = 18.243 + 0.816 + 0.581 + 0.528 + 0.631 + 0.293 - [0.35- +0.444+1.115+0.653]
= 21.092 - [2.562] = 18.53 ha

5.1.10 Village Name - Noselu Village Code - 11163

a) Village land 35.782 ha
b) Forest settlement With Sigad forest

	Proportion (Percent)	Area (ha)	Honoured
Grass	0.905	682.4	1
Shrub	0.905	50.7	1

c) Revenue settlement Nil
d) Agriculture land owned elsewhere

S.No.	Village	Area (ha)	Beneficiary*
1.	Jairaj	0.407	1
2.	Kamdoli	5.622	1
3.	Kamera	0.036	1
4.	Kandara	1.14	1
5.	Teuthiya	0.059	1

* 1 - Harvested by the village (Noselu)
0 - Harvested by outsiders

e) Agriculture land owned by outsiders

S.No.	Village	Area (ha)	Beneficiary**
1.	Doblya Malla	1.136	0
2.	Jairaj	0.143	0
3.	Kamera	0.616	0
4.	Kandara	0.236	0
5.	Nakot	0.81	1
6.	Rithai	1.027	0
7.	Teuthiya	0.129	0

** 1 - Harvested by the village (Noselu)
0 - Harvested by outsiders

Biosystem = 35.782+0.407+5.622+0.036+1.14+0.059+0.81 - [1.136+-0.143+0.616+0.236+1.027+0.129]
= 43.856 - 3.287
= 40.569 ha

The examples illustrate the procedure for estimating the biosystem for the village. It was observed that in resource deficient villages, agricultural land was shared by several outsiders (more common in villages developed out of family split). It was also observed that village forests (Van Panchyat) were mostly found in older villages (Thokdars).

Table 5.1. Biomass system defined for various selected villages

Village	Land (ha)	Biosystem (ha)	Difference (%)
Agrora	102.1	98.34	3.7
Thapli	173.6	186.1	7.2
Ghiri	54.0	56.5	4.6
Kadola	35.8	34.4	5.0
Jaspur	56.8	56.8	0
Noselu	35.8	40.6	13.4
Teuthiya	21.7	15.6	28.1
Andriyon	18.2	18.5	1.6
Toli	61.7	63.3	2.5
Chamkot	30.5	22.3	26.9

Difference (in term of percentage) between biomass system of a village and the total village land was calculated and detailed in Table 5.1. The perusal of the data reflected that the difference was higher for the villages which generated lower biomass yield (Table 5.2) and had small land holding. It became all the more essential to define biomass system for such villages, specially, when the biomass system was less than the village land, like in village Teuthiya and Chamkot where biomass system was almost 3/4th of village land and generated biomass as low as 130 and 71 tonnes, respectively.

It was observed that the biomass system of village Jaspur was limited to the village land only, which implied that for one reason or another, people of this village would have to fulfil their energy needs by local resources. Other biomass resources may not be available.

5.2 Biomass supply

Sustainable supply from various biomass sources i.e., agricultural crop residues, grasses, shrub and trees yielding fodder, fuel or timber in selected villages was estimated. The information generated and analysed for ten villages has been presented in the following sections.

Table 5.2. Sustainable biomass supply in various selected villages

(In tonne of dry matter)

Village	Cowdung	Agricultural crop residues	Grass	Shrub	Tree Scattered	Canopy	Total
Agrora	58.2	66.9	165.4	120.5	12.9	10.0*	423.9
Thapli	119.4	216.0	286.0	208.4	28.5	37.5	895.8
Ghiri	44.0	11.4	80.8	58.9	5.8	-	200.9
Kadola	28.0	22.9	65.6	47.8	4.1	-	168.4
Jaspur	71.0	43.3	103.9	75.7	6.9	-	300.8
Noselu	18.8	54.0	75.1	45.2	4.0	20.2	217.3
Teuthiya	7.9	25.2	23.4	33.8	5.8	-	96.1
Andriyon	6.8	5.0	49.3	31.5	3.7	2.4	96.3
Toli	57.7	64.7	109.0	79.4	6.6	[illegible]	317.4
Chamkot	8.7	7.3	23.2	15.1	2.0	-	56.3

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* Not included (Extraction stayed)

The data presented in Table 5.2 revealed that irrespective of resource, the highest biomass yield (895.8 tonnes) was avilable in village Thapli followed by village Agrora (493.9 tonnes). Whereas, the lowest biomass yield (56.3 tonnes) was generated in village Chamkot. The biomass yield in village Chamkot was less than that produced in the smallest village Andriyon. This may reflect the low productivity of various biomass resources in village Chamkot. It was observed that in all the villages, the major share of biomass was contributed by shrubs followed by grasses. It was also noticed that only four villages had forest canopies. Forest canopies, either within or outside the village, are harvested to meet fuel, fodder and timber demands.

Besides the village forest, a few villages had rights on the Adwani and Sigad forests biomass from which was being extracted. Based on the assumption that the biomass being harvested by a village was proportional to the number of families, the share of individual village was computed. In total 77 villages (3784 families) harvest Adwani forest whereas 52 villages (2874 families) harvest the Sigad forest. However, from Irgad micro-watershed only 13 and 18 villages extract biomass from Sigad and Adwani forests respectively (Table 5.3 and 5.4).

Table 5.3. Proportionate share of the villages harvesting Sigad Forest

No.	Village	Code	No. of family	Percent	Proportion of G.S.
1.	Rithai	11191	43	1.496	0.01496
2.	Chamkot	11042	5	0.174	0.00174
3.	Kandara	11112	77	2.679	0.02679
4.	Andriyon	11004	12	0.417	0.00417
5.	Doblya Malla	11057	26	0.905	0.00905
6.	Dobalya Talla	11058	5	0.174	0.00174
7.	Jairaj	11097	26	0.905	0.00905
8.	Kamera	11107	52	1.809	0.01809
9.	Nauselu	11163	26	0.906	0.00906
10.	Tieutiya	11207	29	1.009	0.01009
11.	Molthi	11154	76	2.644	0.02644
12.	Nisni	11167	257	8.942	0.0842
13.	Uregi	11213	173	6.019	0.06019

Table 5.4. Proportionate share of the villages harvesting Adwani Forest

No.	Villages	Code	No. of family	Percent	Proportion of G.S.
1.	Bhimalli Talli	11037	73	1.457	0.14570
2.	Bhimalli Malli	11036	40	0.798	0.00798
3.	Ali	11001	23	0.457	0.00457
4.	Bhakra Chak	11030	5	0.100	0.00100
5.	Palsain	11176	34	0.678	0.00678
6.	Dwarkhil	11072	24	0.479	0.00479
7.	Kebars	11117	176	3.512	0.03512
8.	Bangargaon	11016	34	0.678	0.00678
9.	Kapholgaon	11115	35	0.698	0.00698
10.	Masun	11147	102	2.035	0.02035
11.	Pali	11174	44	0.878	0.00878
12.	Kandai Malli	11109	75	1.496	0.01496
13.	Surari	11201	3	0.060	0.00060
14.	Raidul	11184	113	2.255	0.02255
15.	Bhansaru	11028	24	0.479	0.00479
16.	Satmukh	11192	15	0.299	0.00299
17.	Kandai Talli	11110	70	1.397	0.01397
18.	Rachulli	11183	101	2.015	0.02015

5.2.1. Trees

Out of the four villages having forest canopy, the highest sustainable yield was recorded in Thapli (37.5 tonnes) and lowest in village Agrora (10.0 tonnes). The sustainable yield from Agrora forest is not extractable because harvesting the resource has been stayed by the district court. A case was pending with the local district court to define the share of village Agrora and Dang, over the resource. The lowest wood yield was recorded for village Andriyon (2.4 tonnes).

The sustainable yield was estimated by the following method:

Village Agrora

Area - 5.86 ha
Mean Basal Area - 11.8 m^2/ha
Crop Height - 26.8
Form Factor - 0.3047
Growing Stock - Form Factor x Basal Area x Crop Height x Area
- 0.3047 x 11.8 x 26.8 x 5.86
- 564.65 m^2
- 376.439 tonnes
Sustainable Yield = (2 x Growing Stock)/R
R = 75 years
Sustainable Yield = (2 x 376.439)/75 = 10.038 tonne (Extraction Stayed)

Village Thapli

Area - 30.66
Mean Basal Area - 14.678
Crop Height - 15.39
Form Factor - 0.3047
Growing Stock - 30.66 x 14.678 x 15.39 x 0.3047
- 2110.3 m^3
- 1406.88 tonnes
Sustainable Yield = (2 x 1406.88)/75 = 37.5 tonnes

Village Noselu

Area - 17.19 ha
Mean Basal Area - 11.1 sq.m.
Crop Height - 19.56 m
Form Factor - 0.3047
Growing Stock - 0.3047 x 19.56 x 11.1 x 17.19
- 1137.20 m^3
- 758.14 tonnes
Sustainable Yield = (2 x 758.14)/75 = 20.22 tonnes

Village Andriyon

Area - 2.36 ha
Mean Basal Area - 10.3 sq.m.
Crop Height - 18.3 m
Form Factor - 0.3047
Growing Stock - 0.3047 x 18.3 x 10.3 x 2.36
- 135.54 m^3
- 90 tonnes
Sustainable Yield = (2 x 90)/75 = 2.41 tonnes

The data in Appendix 1 presents the quantum of biomass growing on scattered trees standing on various strata in different villages. It was observed that generally miscellaneous species generate the larger portion of the tree biomass, however, Chir, Kharik, Tun and Bheemal also dominated tree biomass. It was evident from the appendix that for all the villages except Jaspur and Chamkot, agricultural land contributed most of the biomass. In village Jaspur and Chamkot, major share of woody biomass was produced in village common lands. It was also observed that highest woody biomass was generated in village Thapli (712.4 tonnes), followed by village Agrora (332.0 tonne). But, the lowest was recorded in village Andriyon (67.4 tonnes).

5.2.2. Shrubs

The shrub biomass generated per hectare was calculated by applying the general equation to the data collected for different shrub species during quadrate study. Average shrub production per quadrate was used to calculate the per hectare production and then it was averaged to yield the watershed level standard. The results thus obtained are described in Table 5.5.

Table 5.5. Shrub production in selected villages

(in kilogram/ha)

Quad. No.	Agrora	Kadola	Nauli	Ghiri	Nausin	Toli	Avg.
AVG.	493.88	14845.59	6796.99	5287.50	7488.24	7640.58	7092
STD.	259.42	6690.28	2463.52	6017.96	2934.28	775.95	

Among the villages shrub production varied between 493.88 and 14845.59 kg per hectare with standard deviation ranging from 259.42 to 6690.28 in different villages. The average shrub production was observed to be 7092 kg/ha and half of it (i.e. 3546 kg/ha) was the sustainable yield.

It was further observed that highest sustainable shrub yield (208.4 tonnes) was in village Thapli followed by village Agrora where shrubs recorded a production of 120.5 tonnes. However, the lowest production, recorded in village Chamkot was 15.1 tonne of shrub biomass (Table 5.2).

5.2.3. Grass production

It was observed that highest grass biomass (286.0 tonnes) was collected in village Thapli. It was followed by village Agrora,where grass production was 165.4 tonnes. However, the lowest production recorded in village Chamkot was 23.2 tonnes for grass (table 5.6).

Table 5.6. Annual grass production in various villages

S.No.	Village	Production
2.	Thapli	286.03
3.	Ghiri	80.8
4.	Kadola	65.6
5.	Jaspur	103.86
6.	Noselu	75.07
7.	Teuthiya	23.38
8.	Andriyon	49.26
9.	Toli	109
10.	Chamkot	23.20

5.2.4 Agricultural crop residue

Production of agricultural crop residue varied with the change in the agricultural land, as the other factors i.e., the productivity of grains and the grain to straw ratio were constant. This was calculated as the sum of crop residues generated by the major crops only.

The main rabi crops, wheat and barley, did not require dehusking as grains were extracted directly after threshing. Only one grain to straw ratio was established for the rabi crops and is presented in Table 2.8.

It was reflected by the data detailed in Table 5.2 that agricultural crop residue production ranged from 5.0 tonnes in village Andriyon to 216.0 tonnes in village Thapli.

5.2.5 Available Cowdung

Table 5.7. Available cowdung in various selected villages

Village	Dung production (tonnes)	Dung-cake (tonne)	Percent (%)
Agrora	58.2	29.2	50.2
Thapli	119.4	74.4	62.4
Ghiri	44.0	1.8	4.2
Kadola	28.0	4.4	15.8
Jaspur	71.0	13.7	19.2
Noselu	18.8	0	0
Teuthiya	7.9	1.0	12.7
Andriyon	6.8	0	0
Toli	57.7	4.0	7.0
Chamkot	8.7	3.0	34.7

The data collected on dung production, tabulated in Table 5.7, revealed that the highest amount of dung was produced in village Thapli (119.4 tonnes dry matter per year) and the lowest in village Andriyon (6.8 tonnes dry matter per year). The data on dung-cakes indicates that dung-cakes were not prepared in Noselu and Andriyon, whereas in Thapli about 62 per cent of dung was being used for dung-cake production. It was noticed that the dung production per cattle varied between 5.48 kg/day in village Jaspur and 1.97 kg/day in village Teuthiya.

5.3 Biomass consumption

In the study area it was observed that the consumption of various biomass was highest in village Thapli. The lowest dung-cake and fodder consumption was observed in village Teuthiya, whereas lowest fuelwood consumption was recorded in village Andriyon, and lowest manure as well as timber consumption were recorded in village Chamkot. The data on kerosene oil consumption (Table 5.8) revealed that highest consumption of kerosene for cooking was in village Thapli (20644.8 lts.) but highest consumption of kerosene for lighting was registered by village Toli (1485 lts.).

Table 5.8. Consumption pattern in various surveyed villages

No.	Village	Consumption						
		Fuel-wood (t)	Dung-cake (t)	Kerosene (lt)		Fodder (t)	Manure (t)	Timber (cu.ft)
				Cooking	Lighting			
1.	Agrora	112.7	29.2	10879.4	0	303.7	42.0	4080.0
2.	Ghiri	117.7	108.0	6269.8	0	234.3	52.5	6434.4
3.	Kodala	68.6	404.0	2072.5	48.5	99.2	14.2	2565.0
4.	Jaspur	88.0	13.7	987.4	2288.8	27.6	26.5	5234.5
5.	Chamkot	20.5	3.0	298.1	293.8	47.6	4.4	1218.3
6.	Toli	133.5	4.0	89436.0	1485.0	288.7	39.3	8278.8
7.	Thapli	436.8	74.5	20644.8	734.4	67.3	158.0	23401.3
8.	Teuthiya	33.9	1.0	1638.0	185.6	69.5	13.3	3043.7
9.	Andriyon	13.9	0	586.8	399.6	40.1	6.2	1244.0
10.	Noselu	51.7	0	1555.2	129.6	98.0	31.9	4082.6

5.3.1. Fuelwood

Fuelwood included the wood from shrubs as well as the twigs from trees, however, the both might not be used, together. To assess the resource-wise fuelwood consumption the proportion of wood drawn from shrub and trees was determined (Table 5.9). It was observed that on an average, 9.8 and 90.2 per cent wood was contributed by trees and shrubs, respectively.

Persual of the data showed that the lowest fuelwood was consumed in village Andriyon (13.9 t) and the fuelwood consumption was highest in village Thapli (436.83 t). Moreover, it was also observed that the per capita fuelwood consumption was highest in village Ghiri (1.92 kg/day) and lowest in village Andriyon (1.02 kg/day).

Table 5.9. Total annual consumption of fuelwood village-wise in different villages

Village		No. of family	Population	Total fuel wood consumption		Total twigs (Tonne)	Total shrubs (Tonne)
Name	Code			Per head/ day (Kg)	Total (Tonne)		
Agrora	6001	48	286	1.071	112.74	11.05	101.69
Thapli	6259	130	680	1.764	436.83	42.81	394.03
Ghiri	6090	40	168	1.921	117.73	11.54	106.19
Kadola	6110	15	101	1.86	68.56	6.72	61.84
Jaspur	6107	32	187	1.29	88.04	8.63	79.42
Noselu	11163	24	120	1.18	51.68	5.06	46.62
Teuthiya	11207	15	91	1.02	33.97	3.32	30.56
Andriyon	11004	8	30	1.27	13.90	1.36	12.54
Toli	6264	51	275	1.331	133.49	13.08	120.41
Chamkot	11042	8	36	1.56	20.49	2.00	18.49
Average					107.74	10.56	97.18
Per cent						9.8	90.2

5.3.2. Cowdung

Cowdung was mainly consumed as manure and dung-cakes, however, a small quantity was being used for plastering the floors. Dung-cake consumption was monitored during the survey. To compute the manure consumption it was assumed that 1 tonne of farm yard manure was added per season to every hectare of the agriculture land in each season. In table 5.10 the results are presented.

Table 5.10. Estimate of annual dung consumption in different villages

No.	Village	Agri. land (ha)	Consumption			
			Manure Estimate (tonne)	Dungcake		Total dung (Tonne)
				Per head/day (Kg)	Total (Tonne)	
1.	Agrora	21.01	42.03	0.2	29.22	71.26
2.	Thapli	78.99	157.98	0.30	74.46	232.44
3.	Ghiri	26.27	52.54	0.14	1.53	54.37
4.	Kadola	7.11	14.22	0.11	4.42	18.65
5.	Jaspur	13.26	26.52	0.19	13.65	40.17
6.	Moselu	15.93	31.86	0	0	31.80
7.	Touthiya	6.69	13.37	1.0	1.0	14.37
8.	Andriyan	3.12	6.23	0	0	6.23
9.	Toli	19.63	39.26	4.02	4.02	43.28
10.	Chamkot	2.24	4.48	3.02	3.02	7.50

It was further revealed that largest quantity of cowdung was consumed in village Thapli (232.44 t) and lowest was consumed in village Andriyon (6.23 t). It is also observed that in two villages i.e. Noselu and Andriyon, dung cakes were not being burnt. The highest dungcake consumption per head per day was observed in village Thapli (0.30 kg).

5.3.3 Fodder

The grass and crop residues were fed to animals. Though the availability of different types of fodder may change with seasons but the quantum being fed varies only with livestock. So the resource may either be grass or agriculture crop residue but the amount remains same. It was not possible to determine the contribution of grass and crop residues to fodder as both were fed in different seasons. It was assumed that the entire crop residue was consumed within a biomass system and the remaining fodder was being contributed by grass.

Table 5.11. Total fodder consumption per year in selected villages

No.	Village	Total livestock	Total consumption			
			Fodder		Crop residue (Tonne)	Grass (Tonne)
			Per head/day (Kg)	Total (Tonne)		
1.	Agrora	151	5.5	303.68	66.9	228.68
2.	Thapli	488	3.8	671.34	216.03	455.31
3.	Ghiri	150	4.2	234.33	11.40	222.97
4.	Kadola	69	3.9	99.23	22.95	76.28
5.	Jaspur	148	5.1	275.50	43.28	232.22
6.	Moselu	66	4.0	98.04	53.98	44.06
7.	Teuthiya	46	4.1	69.84	25.22	44.62
8.	Andriyan	27	4.0	40.11	5.04	35.07
9.	Toli	187	4.2	288.72	64.66	224.06
10.	Chamkot	29	4.5	47.63	7.29	40.39

It can be seen from the data in Table 5.11 that in village Thapli, fodder consumption was the highest (671.34 t) and was lowest (40.11 t) in village Andriyon. It was also observed that the fodder consumption per cattle head ranged between 3.8 and 5.5 kg/day. The highest fodder consumption was recorded in village Agrora (5.5 kg/cattle/day) and lowest was registered in village Thapli (3.8 kg/cattle/day). However, in six other villages it ranged from 4.0 to 4.5 kg/cattle/day.

5.3.4 Timber

Most of the households in the study area used wood extensively for roofing and floorings, even the balcony and the passage on first floor were made of wood. All the planks, supports, doors and windows were measured for the selected villages, and average timber consumed per household was used for computing total timber consumption.

Data pertaining to timber consumption revealed that though the timber consumption was highest in village Thapli (23401 cu.feet) and lowest in village Chamkot (1228 cu.feet), the highest timber consumption per family was 202 cu.feet in village Teuthiya and the lowest was 152 cu.feet in village Chamkot (Table 5.12). It was interesting to note that except for the village Agrora, the timber consumption did not vary much.

Table 5.12. Village-wise timber consumption

No.	Village	Total wood consumption in village (Cu. feet)	Consumption per family (Cu. feet)
1.	Agrora	4080	85
2.	Thapli	23401	180.0
3.	Ghiri	6434	160.8
4.	Kadola	2565	171.0
5.	Jaspur	5234	163.5
6.	Noselu	4082	170.1
7.	Teuthiya	3043	202
8.	Andriyon	1244	155
9.	Toli	8278	162
10.	Chamkot	1228	152

5.4 Stress computation

The present stress on different resources has been dealt in the following text and shown in Table 5.13. The perusal of the data revealed that stress for cowdung was highest in village Thapli and lowest in village Jaspur. In village Thapli, the cowdung consumption was almost double (1.95 times) the supply. Whereas in village Jaspur, cowdung consumption was almost half (0.565 times) of the supply. It also may be noticed that in Noselu and Andriyon, dung-cake consumption was nil (Table 5.10). Yet, a stress was reflected due to normative FYM consumption in the villages. Stress on agricultural crop residues was unity because of the assumption that total supply of the crop residues was consumed within the biomass system.

Highest stress for grasses was (2.8) and the lowest (0.5) was observed in village Ghiri and Noselu, respectively. Generally, a scarcity of grass was observed in all but two villages i.e., Andriyon and Noselu. It may also be noticed that in village Noselu and Andriyon, sufficient grass and agricultural crop residues were being generated to meet the local fodder requirement. Also, it may be observed that in the stressed villages, grass consumption ranged from 1.1 to 2.7 times the supply.

The stress computed on shrub availability reflected that only village Andriyon was self-sufficient to meet fuel requirement from the local resources. In all other villages shrub consumption was higher than the shrub production.

Against the supply of firewood from trees, the consumption ranged between 0.2-2 times the sustainable yield. It was lowest (0.208 times) in village Noselu and was highest (1.983 times) in Ghiri. Perusal of the data revealed that four villages were stressed and four others just marginally escaped. Though in some villages, the sustainable supply was double the consumption, yet had been classified as marginally stressed because mostly the sustainable yield was being contributed by miscellaneous species that includes fruits and poor fuelwood species chiefly (Table 5.14).

Table 5.13. Stress estimated for various biomass sources in selected villages

Resources		Cowdung (t)	Agri. Residue (t)	Grass (t)	Shrub (t)	Tree (t)	Timber (t)
Agrora	Supply	58.2	66.90	165.35	120.49	22.95	
	Consumption	71.25	66.90	236.78	101.69	11.05	
	Stress	1.22	1	1.43	0.84	0.85	
Thapli	Supply	119.40	216.03	286.03	208.40	66.96	
	Consumption	232.44	216.03	455.27	393.99	42.81	
	Stress	1.95	1	1.59	1.89	0.65	
Ghiri	Supply	44.00	11.40	80.80	58.88	5.82	
	Consumption	54.38	11.40	222.93	106.20	11.54	
	Stress	1.02	1.24	12.76	1.80	1.98	
Kadola	Supply	28.04	22.95	65.60	47.80	4.14	
	Consumption	18.65	22.95	76.28	61.85	6.72	
	Stress	0.67	1	1.16	1.29	1.62	
Jaspur	Supply	71.04	43.03	103.86	75.69	6.91	
	Consumption	40.17	43.03	232.22	79.42	8.63	
	Stress	0.57	1	2.24	1.05	1.25	
Noselu	Supply	18.84	53.99	75.07	45.18	24.25	0.92
	Consumption	31.86	53.99	44.10	46.62	5.06	3.85
	Stress	1.69	1	0.59	1.03	0.21	4.18
Teuthiya	Supply	7.94	25.23	23.38	33.81	5.77	1.03
	Consumption	14.67	25.23	44.62	30.56	3.32	2.87
	Stress	1.85	1	1.91	0.90	0.58	2.79
Andriyon	Supply	6.85	5.04	49.26	31.50	6.12	0.43
	Consumption	6.23	5.04	35.07	12.54	1.36	1.17
	Stress	0.91	1	0.71	0.40	0.22	2.73
Toli	Supply	57.66	64.66	109.00	79.00	6.65	
	Consumption	43.28	64.66	224.05	120.42	13.08	
	Stress	0.75	1	2.06	1.52	1.97	
Chamkot	Supply	8.74	7.30	23.20	15.07	1.97	2.76
	Consumption	7.50	7.30	40.34	18.49	2.01	1.15
	Stress	0.86	1	1.74	1.23	1.02	0.42

Table 5.14. Woody biomass shared by miscellaneous species in different villages

Villages	Total biomass (Tonne)	On Miscellaneous species (Tonne)	(Per cent)
Agrora	332.0	73.1	22.0
Thapli	712.4	369.8	51.9
Ghiri	140.6	82.9	58.9
Kadola	103.3	51.7	50.1
Jaspur	172.7	56.0	32.4
Noselu	92.6	35.5	38.4
Teuthiya	116.4	55.1	47.3
Andriyon	67.4	41.9	62.1
Toli	166.1	85.5	51.5
Chamkot	198.2	78.4	39.6

However, only two village were observed to be comfortable with regard to firewood supply. In village Noselu as well as Andriyon it was observed that sustainable fuelwood supply from trees was approximately five times the consumption. It was interesting to note that in both the villages dungcakes were not being used. This might imply that dungcakes were being consumed only in case of higher stress otherwise people prefer to make FYM from all the available dung.

Perusal of secondary data revealed that four villages have rights on Sigad forest to harvest timber (with prior permission only). As shown in Table 5.13, it was found that only for Chamkot village the annual timber demand might be met by the rights released from the forest. In the remaining villages, stress for timber demand ranged between 2.7 and 4.1. It was implied that the wood released under the rights could not satisfy the local timber requirement.

On reviewing the data, it was observed that in six villages, the stress was chiefly caused on grasses due to fodder consumption, whereas in only one village it was caused on shrubs for firewood. However, in three villages, stress was primarily on cowdung which indicated that agricultural fields were not being adequately fed with FYM.

In village Agrora higher stress was observed for grasses (1.4) followed by cowdung (1.2) however, fuelwood demand was being met by the local supply only. In village Thapli and Noselu, stress was mainly on available dung i.e. 1.2 and 1.7 followed by stress on shrubs which was estimated to be 1.9 and 1.0, respectively. Firewood was causing severe stress (1.3) on shrubs in village Kadola indicating that for few weeks villagers might have to harvest some other sources outside their biomass system. In six villages fodder consumption exceeded the grass supply and villagers would have to purchase or harvest grasses from neighbouring villages or forests. In all the villages except Agrora and Teuthiya, primary stress was on grasses, followed by shrubs. However, in village Agrora as well as Teuthiya, the stress was mainly observed on grass followed by available cowdung. It was interesting to note that village Andriyon was nearly self-sustainable i.e. except for timber, all other requirements for biomass could be met with the local resources alone. This was probably because of lower consumption by the small population of the village.

5.5 Biomass plans

In this section, we have attempted to develop biomass plans for base case scenario i.e. if the present trends continued in supply and consumption continue, what are the opportunities for developing biomass resources to achieve the objective of sustainable resource management. In the final report these plans will be refined and alternative scenarios will be developed.

5.5.1 Biomass management plan - village Agrora

About village

This village was the headquarters of the Revenue Department i.e. one Kanoongo and three Patwaris. The Irgad rivulet passes through the village at the lowest elevation and does not irrigate more than half a hectare of land. A dam for a drinking water scheme is under construction. The Pauri-Kotdwar/Agrora road passes through. The village extends over 101.82 ha and much of the land faces southwards. As per the Patwari records, agricultural land covers 27.84 ha whereas village common land (including all barren land) extends over 66.74 ha. Besides this 5.58 ha is village Panchayat forest, from which extraction has been stayed. The village does not have rights over forest or revenue lands outside the village area. Agrora enjoys all the civic amenities - it has a local market, dispensary, two primary schools, a few 'Pakka' houses and a dish-T.V. antenna catering to the demands of the few families in the market area.

People of the villages Kolri, Dang and Ayal have agricultural land in this village and people of Agrora have land in Dang, Thaplue and Sarkayanawalla villages. Agricultural fields in Sarkayanawalla were not being cultivated by Agrora people. One observes large patches of barren land where soil depth was hardly 1 cm at most of the sites and on few aspects, rocks were visible. At the same time, agricultural fields were also tree-less, and on bunds grasses and Kirmora shrubs were growing. On homesteads, Kharik, Tun and Citrus were dominant tree species. For last the 15-20 years people have felt the need for plantations and have encouraged plantations. This has resulted in very good natural regeneration. Many agricultural fields were lying barren which have led to increased soil erosion. Check-dams were constructed but all of them got filled within a year.

The village is dominated by Rajputs and Brahmins. Generally people seem to be financially prosperous. The Gram Sabha of Agrora also covers village Dang (and village Bhyanu). The villages have a separate Van Panchayat which is responsible for the management of the village forest. At present it is maintaining the papers only, related to the judicial proceedings of the suit filed by the individuals of village Dang at Pauri Court for their share in Agrora's village forest. Mahilla Mandals or Yuvak Mandals were ineffective, however, a few ladies and youth were energetic and could spare some time community service. Youth are mostly educated and are at least graduates.

Present biomass situation

The general fuel-mix reflects that primary fuel source is shrubs, though a small amount of fuel and fodder is supplied from lops and tops. All the families use kerosene as well as dung-cakes for cooking. Some of the families admitted that for a few days of the year they resort to stealing or illicit harvesting of the resources from nearby revenue lands. Only family uses LPG. Agricultural crop residues were generally used for fodder purposes. Jhangora residues were also burnt but not for providing energy. The village land was mainly occupied by Chir, Tun and Kharik whereas the barren land had Tungla shrub. By and large people were able to meet their demands by the resources in the village, or on their agricultural lands in the neighbouring villages.

Total dung production (the available dung) was 58.20 tonnes (dry dung) of which 50 per cent was used for dung-cakes, i.e. 29.23 tonnes. Against this consumption was estimated to be 29.47 tonnes.

Agricultural crop residues were generally used as fodder, however Jhangora's residues were burnt without any constructive use. In both the seasons i.e. kharif and rabi, 66.92 tonnes of crop residues collectively were produced from the major crops.

Total grass production in the village was found to be 158.49 tonnes. However, the total consumption of fodder was about 300 tonnes.

Table 5.15. Biomass supply-demand balance sheet for village Agrora

(in tonnes)

	Sources	Total Supply	Use	Consumption
1.	Dung (for fuel)	32.04	Fuel	29.47
			Manure	42.02
2.	Agricultural crop residues	66.92	Fodder	66.92
3.	Grasses	158.49	Fodder	236.78
4.	Shrub (dry wt.)	120.49	Fuel	101.69
5.	Trees (Scattered tree)	12.91	Fuel	11.05
	Tree canopy (Stayed)	10.04	Fuel	
6.	Annual Timber	-		4.17
	Total	400.89		495.10

In Agrora, Tungla and Kirmora were the major species on barren lands and bunds of agricultural land, respectively.

The total production of shrub biomass on all common lands and bheeta land was 120.49 tonnes (dry matter). Shrubs as well as the lopped tree biomass were being used as fuel. Out of total fuel wood consumption of 112.74 tonnes, shrub biomass contributed 101.69 tonnes and 11.04 tonnes was shared by lopped material. Sustainable yield from trees was 22.9 tonnes, of which 10.04 tonnes available from village forest was not extractable because of judicial 'stay'.

Chir was the major species, however, Tun and Kharik were also present in significant amount. All the growing stock can be differentiated very clearly in continuous canopy (stand) and scattered trees or groups of trees. The stand or Village Panchayat Forest is under dispute and because of the 'Stay-order', it is not open for extraction, which essentially means people do not have an access to a growing stock of 574.48 m^3

(382.98 tonnes). The growing stock standing over village common land (other than village forest) is 484.05 cu.m. of wood which can generate a sustainable yield of 12.9 tonnes covering both timber and small wood.

As observed in Table 5.15, annual timber consumption (4.17 tonnes) was only 5 per cent of the total timber consumed in the village and supposed to be replaced within next 20 years. The consumption was based on actual survey of the wood used in few selected households of the village.

Future projections

It has been assumed that the biomass supply in the village would not change over the years. Annual yield of grass, shrubs and agricultural crop residues depends upon the land available, which should not change except for the agricultural fields turning barren. Cowdung supply should vary only with livestock. However, the growing stock would also not vary because the stock was being lopped every year.

The consumption of various biomass resources would vary with growth rate of human population and livestock. However, the consumption of wood for timber was calculated by the following method:

Table 5.16. Growth rate for human population

Year	Population	Rate	Average
1971	172	1.02	1.02
1981	227		
1991	286	1.02	

It has been assumed that fodder requirement shall rise by 1.2 per cent (adopted earlier by watershed department for the area) over a decade.

Table 5.17. Stress computed on biomass resources in village Agrora

Source	Biomass supply (t)			Consumption (t)			Stress		
	1992	2002	2012	1992	2002	2012	1992	2002	2012
Cowdung[2]									
Manure	28.77	25.58	22.10	42.02	20.02	20.12	1.45	1.64	1.90
Cakes	29.47	32.62	36.10	29.47	42.02	42.02	1	1	1
Crop residue	66.92	66.92	66.92	66.92	66.92	66.92	1	1	1
Grass	165.35	165.35	165.35	236.78	266.85	300.58	1.43	1.61	1.82
Shrubs	120.49	120.49	120.49	101.69	112.47	124.48	0.84	0.93	1.03
Trees	12.64	12.64	12.64	11.05	12.23	13.54	0.87	0.97	1.07
Timber	-	-	-	4.17	4.17	4.17	-	-	-

The projections for timber requirements were calculated as follows:

It was assumed that 80 per cent of timber consumed would be replaced within the next 25 years and remaining 20% after 40 years.

80% of Total Timber Consumption = 77.032 x 0.8 = 61.6256

The timber being consumed every year in a span of 25 years.

$$\text{Timber Consumed/year/family} = \frac{61.626}{25} = 2.465 \text{ tonnes}$$

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[2] Cowdung supply for manure varies with dung-cake consumption. As dung-cake consumption would increase with human population, over decades, this would cut down the supply, of Farm Yard Manure to agricultural fields. In village Agrora, available dung was 58.2 tonnes (Dry) which would not change as long as livestock population was constant.

20% of total Timber Consumption = 23.11 tonne
The timber being consumed every year in a span of 40 years.

$$\text{Timber Consumed/year/family} = \frac{23.11}{40} = 0.578 \text{ tonnes}$$

Total Timber Consumed/year = 2.465 + 0.578 = 3.043 tonnes

Biomass management plan

Cowdung

Its consumption is expected to rise about by 4.4 percent by 2002 AD and another 4.6% by 2012 AD. To meet this consumption, cowdung production shall have to be raised to 74.64 t by 2002 AD and 78.12 t by 2012 AD.

- There are only 30 buffalos and 95 cows. Largescale extension programmes should be initiated to popularize buffaloes over cows, which shall increase milk production for trade, cow-dung for dungcakes and shall increase the number of stall-fed stock.
- It is essentially required to increase the number of stall-fed animals i.e. sheep and goats should be minimized. People can easily switch over to bigger animals.
- Six families have more than five adult animals. They may be encouraged to have individual family-size biogas plants.
- If all the dung is processed through biogas plants, the gas thus produced would replace the dung-cake consumption, and the slurry produced would satisfy the need of 46.5* tonnes of dry manure (more than present requirement).

To use this resource, villagers shall have to think in terms of a community biogas plant.

Fodder

a) Agricultural crop residues: In both the seasons collectively, 66.92 tonnes of crop-residues were produced, of which 53.26 tonnes were generated in Kharif season and 13.66 tonnes in Rabi season. All the crop residues were being stacked on trees and would be used as fodder when grass is scarce.

b) Grasses: Perusal of the overall picture of fodder consumption reflects that at present 52 families are consuming 303.7 tonnes of fodder annually which means 16 kg per day per family. Present resources are able to supply 12 kg of fodder per day per family annually. Both agricultural crop residues and grass were used as fodder. The sustainable yield from tree resource (10.04 tonne)[3] could not meet the demand for 78 tonnes.

- At the present level of fodder supply any increase in livestock population cannot be encouraged
- Improved cultivars may be introduced such as Napier hybrid or Cenchrus cilaris in order to increase grass productivity to 20 t/ha from the present level of 2.287 tonne/ha. If 30 ha of land is set aside for improved grass production out of total 72.3 ha land (on which grass grow), and even if the improved cultivator produces half of the potential yield, it will be possible to meet the fodder requirement for next two decades.

With a growing tendency to encroach common lands it is possible that all the resources on common lands may be shared by only 30 families and remaining should have to depend on their own resources. Panchayat should curb this tendency to encroach village common lands, as it would restrict the access to the resource by the masses.

- Major grass supply came from the land which was taken over by a local education institute (G.B. Pant University, Srinagar) for plantations. The land included some private land also. Besides this, the area above the agricultural fields of Bhyanu, Agrora and Kolri and up to the Panchayati forest may also be set aside for grass production. The areas might be opened for harvesting once a year i.e. in November.

* **Note** - Proper protection i.e. erecting boundary wall and employing a chowkidar is a must besides a general understanding about restricted grazing.

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[3] Depending upon the age of trees, the sustainable yield includes fodder, fuel and timber. So the tota, of 10.04 tonnes shall not be fodder or fuel alone.

Shrubs

This is a major source of fuel in the area because felling of trees is banned. At present, total production from village common land and Bheeta land is 120.49 tonnes against the consumption of 101.62 tonnes[4].

More or less the village is able to meet its fuel requirements on its own (by local resources). A few people go out probably because of the reduction in shrub supply due to encroachments into the common land.

- Shrubs may be planted all along the path to village Kolari, site opposite the Patwari-Chowki, land on the banks of Irgad, hillock near the fields where two bamboo clumps were growing, barren land between 'Kolri wala Rasta' and Nursery Area, land opposite the Kadola waterfall, the land around the Chir plantation near Panchayati village forest, and also the land owned by Gram Sabha.
- By increasing the productivity from 7.0 tonnes/ha to 7.5 tonnes/ha in the next 20 years (it is achievable in three years) demand for 124.48 tonnes fuel per year can be met by local resources.

Most of the shrub stock was small which reflected a higher grazing pressure. All the land which would be brought under shrub plantation should not be grazed for at least two years and this would raise the shrub yield to the required level.

Trees

There are clearly two categories of tree cover - one is continuous canopy and other is sparse or open canopy, scattered over homesteads, agricultural land and village common land.

The continuous canopy i.e. village Panchayat Forest has a middle-aged stock which is expected to grow at 2% per annum and mature around 2035 AD for timber extraction. Since extraction has been stayed by Court orders, the

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1. With the increasing tendencies to encroach common land it would be possible that all the common property resources i.e. grass, shrubs as well as trees may be shared by only about 30 families, who have agricultural fields adjoining the common land; leaving others to depend on their own resources or illicitly harvest from far away fields leading to numerous disputes. Panchayats should curb the tendency to encroach village common lands as it not only reduces the access to the resource by masses but also reduces the impact of various proposed improvement treatments as well as development plans.

2. Supply figures seems slightly over estimated not because of production but because of invalidity of land records due to encroachments.

lopping yield (10.0 tonne) was also not available which is almost equal to the sustainable yield from rest of the village land (12.9 tonne).

- As soon as ban is lifted, some of the trees should be felled as per the recommendation.

  If ban is lifted in 1997 maintain 380 stems/ha
  If ban is lifted in 2002 maintain 310 stems/ha
  If ban is lifted in 2007 maintain 260 stems/ha
  If ban is lifted in 2012 maintain 190 stems/ha

  A forestry expert should visit the forest stand to advise on the thinnings.

- Special permissions should be granted for cleaning of forest floor as decaying organic matter may act as source of disease and pest inoculum.
- Top thinnings should be carried out, as the plants are fast gaining height rather than diameter[5] due to dense crop and competition for light.

The distribution of number of trees in various girth classes showed that major growing stock came from lower girth classes - the plantations established about 12-25 years ago.

- Encourage plantations on following sites:

Site	**Spp.**
- Near waterfall (Kadola)	Chir
- Opposite Sera	Chir, Kharik, Paiyaan
- Opposite Patwari-Chowki	Kharik, Tun, Paiyaan
- Below Bauri (Kolari)	Kharik, Tun
- Above Kolari (Dhar)	Chir, Kharik, Paiyaan, Banz
- Above Bhyanu village	Chir, Banz, Kharik
- Barren lands between Agrora and Bhyanu	Chir, Kharik, Tun, Banz
- Barren land between Agrora and Kolari	Chir, Acacias, Gurial

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[5] 1. The sustainable yield from this stand was not considered as the available tree biomass.

2. All the yield available from thinnings and loppings shall be fuelwood and not the timber.

Sites above the villages Kolari and Bhyanu were severely degraded and growth of forest species was expected to be slow.

- It would be advantageous to encourage shrubs also.
- It would be suitable economic and commercial activity to plan citrus orchards with assured irrigation from rain water harvest tank by Drip Irrigation System.
- There are some plantations which are about 25 years old. The trees growing near the "Bhairu Ka Dhanda" and plantations on the way to Kolari village, extending down in the valley were performing well and should be lopped for fuelwood.

None of the plantations were going to mature within next 20 years so, for timber this village will have to depend on markets till at least 2030 AD.

- Most of the growing stock was on private lands (private + encroachments). So the self dependence which can be achieved in terms of timber wood would yield benefits to a few families and not all.
- Van Panchayats should try for equitable distribution of resources on encroached land.
- Ensure no more encroachments.

This is the proposed way, by which the demand for various biomass resources may be met for different end-uses.

5.5.2 Biomass management plan - Village Ghiri

About the village

The village Ghiri is 17 km away from Pauri Garhwal on Pauri-Kotdwar road. It is situated about a hundred meters downhill on the right bank of Irgad rivulet. More than 40 per cent of the total land 56.78 ha is under agriculture (rainfed). Because of steep slopes, rocks and impoundment, 11.63 ha of land is not fit for agriculture. There is considerable area under wastelands which is used for grazing (Table 5.18). Generally grasses and shrubs dominate the wastelands.

Table 5.18. Land use pattern in village Ghiri

No.	Category	Land (ha)
1.	Homestead	2.06
2.	Forest	2.46
3.	Grazing	9.88
4.	Barren	1.99
5.	New Wasteland	0.46
6.	Old Wasteland	4.09
7.	Agriculture	24.21
8.	Not fit for agriculture	11.63
	Total	56.78

The village is located about 1.5 km from local market, although the fair price shop and the kerosene depot are hardly 200 m away. People are moderately progressive. Because of a principal of the local Higher Secondary school resides in the area, people are well conversant with the latest developments.

The very first dish-T.V. antenna in the area was installed in this village. A few households have septic-tanks in their cemented houses. Some families raise horticulture plants and nurse various potted-plants to decorate their home interiors. All the children of the village go to school. The village has revenue settlement with Toli village forest for fuelwood which is not honoured but people of the village are known for harvesting own agricultural land in village Kadda and Nauli that yields biomass to this village. Preliminary survey of biomass consumption pattern revealed that shrubs are the major fuel source. Lopped material from tress, kerosene and LPG are also used for the purpose.

The village supports 40 families having 150 domestic animals, that means almost 4 animals per family. Very few agricultural fields are lying fallow. In fact people have to extend agricultural fields in the depressions and use the waste water coming out of a common bathroom for irrigation. Except for depressions, all other land has scanty tree cover. Agricultural fields are almost devoid of trees. Also, the homesteads have sparse shade. Village forest land has a few patches of trees. Some shrub cover also exists but trees are missing. In few plots, plantations were established about 3-5 years ago. Mostly Banj, Toon, Bheumal, Kharik, Khinaa are the dominant species in the standing stock and plantations.

The society dominated by Rajputs, is aware of the fuel and fodder crisis and has initiated plantations on common lands. People use improved chulhas, steel utensils and pressure cookers. It was observed that in anticipation of the fuel crisis people stock shrubs in heaps at a common place to meet the demand in the coming 6-7 years. Also, the fodder is stored in houses to satisfy the demand for 4-5 months. The data in Appendix 1, reveals that a major share of the standing stock was contributed by the miscellaneous species (58.96%). It is also observed that biomass was chiefly generated on homesteads (53.2%), followed by common land (36.8%) and then by agricultural land (10%).

Future projections

We have assumed that the supplies will not change over a period of two decades except for the dung-cake. Dung cake production (supply) is generally equal to its consumption that varies with the human population. In a continuously exploited biomass system, growing stock does not actually increase unless some plantations are mature enough to yield firewood or small wood. All biomass supplies remain constant until some special inputs are applied. The biomass consumption is expected to rise with the human population at the rate of 1.02 per cent. Yet, timber consumption has been assumed to remain constant and fodder consumption is to rise at the rate of 1.2 per cent per decade. The future projections for the biomass supply and consumption in village Ghiri for next two decades have been detailed in Table 5.19.

Table 5.18. Stress estimation in Village Ghiri

No.	Source	Biomass Supply (T)			Consumption (T)			Stress		
		1992	2002	2012	1992	2002	2012	1992	2002	2012
1.	Dung-cakes	1.83	2.02	2.24	1.83	2.02	2.24	1	1	1
	Manure	41.17	41.98	41.76	52.53	52.53	52.53	1.25	1.25	1.26
2.	Crop Residues	11.40	11.40	11.40	11.40	11.40	11.40	1	1	1
3.	Grass	80.8	80.8	80.8	222.9	246.71	273.05	2.76	3.05	3.38
4.	Shrub	58.88	58.88	58.88	106.20	117.54	130.95	2.0	2.21	
5.	Tree	5.82	5.82	5.82	11.54	12.77	14.14	1.98	2.19	2.43
6.	Timber	-								

Present biomass situation

The data depicted in Table 5.18 revealed that the total dung production in village Ghiri was 44 tonnes (dry matter). A small portion of that was being used for making dung-cakes (1.83 tonne) and the major portion (42.17 tonne) was used as farm yard manure.

The farm yard manure consumed in the village was much less than the minimum FYM required in the village (52.53 tonnes). The FYM required in the village was almost 1.25 times the cowdung being consumed as FYM.

In Paddy and Mandwa were major crops in Kharif seasons, whereas wheat was rabi crop. Major crops generate about 11.40 tonnes of crop residues every year that were used as fodder. Grass accounts for a major share of fodder. All the wastelands and common lands generated about 80.8 tonnes of grass. It was observed that grass consumption was 222.9 tonnes per year i.e., almost 3 times the supply. Similar stress was recorded for shrubs. In the village about 59 tonnes of shrubs (dry matter) was gathered but consumption was 106.20 tonnes of shrub wood.

The village was devoid of tree vegetation except for a few patches. The lopped material was consumed as fuel and the trees in the village could generate only 5.82 tonnes of wood annually. And again the annual consumption of 11.54 tonnes fuelwood was twice higher than the fuelwood supply (1.98 times).

For timber, the village was fully dependent on the markets of Pauri and Kotdwar as neither the local resources yield timber nor the village had any rights or concessions over the nearby forests. Timber consumption enumerated in 5 households averaged to 161 cu ft wood per household and the total wood use was estimated to be 6434 cu ft.

Biomass plan

Cowdung

Cowdung consumption is the sum of the dung consumed for dung-cakes and farm yard manure. The present level of dung consumption (54.36 tonnes) is expected to rise from 54.55 tonnes by 2002 and 54.77 tonnes by 2012. Dung consumed for dungcakes is only 3.4 per cent of the total dung consumption and only a negligible rise in total dung consumption i.e., 0.3 and 0.4 per cent is expected over next two decades, respectively.

It has been observed that people have realised the fodder crisis and mainly have stall fed livestock. Only 5 goats are being nursed in the village. All the young stock is either cows or buffalos. It has been observed that because of fodder crisis, even the stall fed stock is taken out for grazing.

If all the households collect at least 3 kg wet dung from the fields i.e., 120 kg dung is collected per day from the grazing animals, it will be possible to meet the annual estimated manure requirement for a few decades. In 2012 AD, 10.77 tonne (dry matter) of dung will be required to manure the agricultural fields. By adopting the above mentioned practice, it will be possible to collect 10.5 tonne of extra cow-dung annually.

Fodder

At present the fodder consumption is almost three times the supply. In both the seasons put together i.e. kharif and rabi, a total of 11.4 tonnes of crop residues is produced over 24 ha of agricultural land. This seems to be a low productivity.

(a) It is suggested that with the cultivation grass like elephant grass, sudan grass, and hybrid napier, the productivity of the wastelands and the bheeta land may be increased to 7.5 tonne per hectare. This way 29 hectare of common land and about 6 hectare of bheeta land can yield 265 tonne of fodder.

(b) Improved cultural practices may be adopted increase to grain productivity to 1.5 tonne/ha and crop residue production to 2.5 tonne/ha under rainfed conditions.

(c) Besides improved cultural practices, measures may be taken to conserve soil moisture, irrigate agriculture fields and reduce erosion losses.

At present level of consumption, the crop residues may serve the purpose for hardly a month. By increasing productivity the same agricultural fields may supply fodder for at least two and a half month i.e., a total yield of 60.7 tonne (an additional production of 49.5 tonne of crop residues).

(d) Though only 0.46 ha of agricultural land has turned barren in last 5 years the tendency should be curbed and all the agricultural fields should be cultivated intensively.

(e) In rabi season, it seems that the agricultural land is not properly utilised. According to the Patwari records only 11 out of 24.2 hectare of agricultural land is being cultivated presently. In these fields, some leguminous fodders may be grown e.g. Guar, Clovers, Shorghum, Lucerus and Mash. This may yield 5.5 tonnes of dry forage per hectare i.e., an additional yield of 50 tonnes from fallow land in rabi season.

By adopting the above mentioned practices, agricultural fields may yield at least 50 tonnes more fodder.

By improving agricultural practices and introducing better grasses in rangeland, it is possible to gather 300 tonne of fodder easily from the village land. This supply can easily meet the fodder requirement for the forthcoming two decades. It is always advisable to open half of the range land in summer and other half in winter (rotational grazing). It is still better if stall fed livestock is increased in number and people harvest the grasses in sequential method from various parts of the grass-lands.

Fuel

Fuelwood is contributed by shrubs and trees. For both the sources, the consumption is almost twice the supply. Against a sustainable supply of 58.8 tonne of fuelwood from shrubs, the consumption is 106.2 tonne. Similarly, against a supply of 5.82 tonne of lopped wood from trees the consumption is 11.54 tonnes i.e., 1.98 times. There are 8 plots of common land extending from the grazing land near the bridge to village Kadola and upto Thapli forest. All the sites, except two near the Thapli forest, are dominated by grasses and a scanty growth of shrubs is observed. On the two sites near the Thapli forest and the village forest land (opposite village Nausin) some plantations have been established 3 years ago. Mainly Kharik, Chir, Mahua, Acacia and Bunj have been planted and fuel yield is expected only after 20 years (with good survival). On these site rocks are visible, soil is shallow and shrubs should be planted at a spacing of 1m x 1m.

All other sites lying close to the river bed are suitable for plantations. Species like Chir, Kharik, Manipuri Banj, Acacia Mollisima, Leucaena Leucocephala, Melia Azedarach Toona Ciliata, Bheemal, Semal, Khinus and Pyrus Patia may be planted at a spacing of 2m x 2m. The spacing may be reduced on the site, opposite to village Nausin, where some agricultural fields are lying barren.

On all the sites shrubs and tress can be planted. On the western aspects more trees can be planted whereas on southern aspect shrubs can be encouraged.

(a) For first two years, on all the sites improved grasses can be planted and rear to increase the fodder yield. Precaution about sequential harvest should be taken.

(b) In third and fourth year, plantations of shrubs and trees can be developed on all common lands and bheeta land.

(c) Free grazing should be restricted and only sequential grazing may be allowed. Proper care must be taken to ensure establishment and growth of the plantations.

(d) The plantations shall yield at least 2 tonnes (dry matter) per hectare from fifth year onwards. An additional yield of at least 70 tonne. A total supply of 135 tonnes shall take care of the major fuel demand till 2012 AD

Keeping in view the shortage of fuelwood, it is suggested to install 3 family size ($2m^3$) of biogas plants in the first year and by the third year the number may be increased to 11. These plants, while working for 300 days in a year will replace 10.8 tonne fuelwood in first year, whereas from third year onwards will replace 40 tonne of fuelwood per year. To replace this much fuelwood it is essential to maintain the present level of livestock that in turn needs improvement in range land so that fodder supply is ensured.

To further reduce the pressure on natural woody resources solar-cookers can be introduced. Generally people boil the major part of their meals and rice is the main diet. So solar-cooker fits into the traditional cooking system and people's requirements.

In this manner, the essential requirements of various biomass for different enduses may be met for the village Ghiri.

These plans will be discussed with villagers and concerned authorities at village level as well as at district level.

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Appendix 1: Woody biomass supply in various selected villages

(in tonne)

1. Village - Agrora

Species	Home	Agricul.	Common	Total	Per cent
CHIR	0.00	125.13	25.07	150.20	45.24
KHARIK	3.01	48.87	0.60	52.48	15.81
TUN	0.18	56.00	0.00	56.18	16.92
MISC.	52.47	14.73	5.93	73.13	22.03
Total	55.66	244.73	31.60	331.99	100.00
Per cent	16.77	73.72	9.52		

2. Village - Thapli

(in tonne)

CHIR	0.13	18.27	5.53	23.93	3.36
KHARIK	65.07	155.60	21.60	242.27	34.01
TUN	29.53	32.40	0.00	61.93	8.69
TIMLA	0.00	0.20	0.00	0.20	0.03
BHEEMAL	8.93	3.07	0.00	12.00	1.68
PAIYAN	0.73	1.33	0.20	2.27	0.32
MISC.	81.33	254.33	34.13	369.80	51.91
Total	185.73	465.20	61.47	712.40	100.00
Per cent	26.07	65.30	8.63		

Continued..

(in tonne)

3. Village - Ghiri

CHIR	0.00	1.00	4.67	5.67	4.03
KHARIK	1.93	29.13	8.07	39.13	27.83
TUN	0.00	1.00	0.00	1.00	0.71
TIMLA	0.00	0.80	0.73	1.53	1.09
BHEEMAL	2.00	4.33	0.33	6.67	4.74
PAIYAN	0.00	0.33	0.00	0.33	0.24
GURIAL	0.00	0.33	0.07	0.40	0.28
KHINNA	0.07	1.33	1.60	3.00	2.13
MISC.	10.07	36.60	36.20	82.87	58.94
Total	14.07	74.87	51.67	140.60	100.00
Per cent	10.00	53.25	36.75		

4. Village - Kadola

(in tonne)

Species	Home	Agricul.	Common	Total	Per cent
CHIR	0.00	2.00	23.87	25.87	25.03
KHARIK	2.40	21.60	0.00	24.00	23.23
BHEEMAL	0.40	1.27	0.00	1.67	1.61
PAIYAN	0.00	0.07	0.00	0.07	0.06
MISC.	22.33	19.00	10.40	51.73	50.06
Total	25.13	43.93	34.27	103.33	100.00
Per cent	24.32	42.52	33.16		

Continued...

5. Village - Jaspur

(in tonne)

CHIR	8.13	3.53	76.00	87.67	50.77
KHARIK	2.40	18.60	0.93	21.93	12.70
TUN	1.27	5.80	0.00	7.07	4.09
MISC.	37.33	7.33	11.33	56.00	32.43
Total	49.13	35.27	88.27	172.67	100.00
Per cent	28.46	20.42	51.12		

(in tonne)

6. Village - Noselu

CHIR	0.00	33.47	7.53	41.00	44.28
KHARIK	3.93	10.80	0.27	15.00	16.20
BANJ	0.00	0.00	0.07	0.07	0.07
TUN	0.20	0.60	0.00	0.80	0.86
TIMLA	0.00	0.20	0.00	0.20	0.22
MISC.	6.00	27.00	2.53	35.53	38.37
Total	10.13	72.07	10.40	92.60	100.00
Per cent	10.94	77.83	11.23		

Continued...

7. Village - Teuthiya

(in tonne)

Species	Home	Agricul.	Common	Total	Per cent
CHIR	0.07	0.13	0.00	0.20	0.17
KHARIK	13.67	35.27	1.33	50.27	43.18
BANJ	0.07	0.13	0.00	0.20	0.17
TUN	0.93	6.80	0.00	7.73	6.64
TIMLA	0.27	0.00	0.27	0.53	0.46
BHEEMAL	0.80	1.13	0.00	1.93	1.66
PAIYAN	0.00	0.07	0.00	0.07	0.06
GURIAL	0.00	0.40	0.00	0.40	0.34
MISC.	21.73	29.60	3.73	55.07	47.31
Total	37.53	73.53	5.33	116.40	100.00
Per cent	32.25	63.17	4.58		

8. Village - Andriyun

(in tonne)

CHIR	4.20	12.00	0.20	16.40	24.33
TUN	0.33	6.40	0.20	6.93	10.29
BHEEMAL	0.60	1.40	0.00	2.00	2.97
REETHA	0.00	0.07	0.00	0.07	0.10
GURIAL	0.13	0.00	0.00	0.13	0.19
MISC.	20.00	19.73	2.13	41.87	62.12
Total	25.26	39.60	2.53	67.40	100.00
Per cent	37.48	58.76	3.76		

Continued...

9. Village - Toli

(in tonne)

CHIR	0.00	3.33	54.27	57.60	34.68
KHARIK	4.93	12.13	0.87	17.93	10.80
TUN	0.27	0.87	0.00	1.13	0.68
BHEEMAL	0.60	2.40	0.33	3.33	2.01
REETHA	0.13	0.00	0.00	0.13	0.08
PAIYAN	0.07	0.33	0.00	0.40	0.24
MISC.	48.80	31.80	4.93	85.53	51.51
Total	54.80	50.87	60.40	166.07	100.00
Per cent	33.00	30.63	36.37		

10. Village - Chamkot

(in tonne)

Species	Home	Agricul.	Common	Total	Per cent
CHIR	0.07	25.13	83.87	109.07	55.03
KHARIK	0.07	2.07	0.07	2.20	1.11
BANJ	0.00	0.13	0.00	0.13	0.07
TUN	2.27	0.53	0.07	2.87	1.45
TIMLA	0.07	0.27	0.00	0.33	0.17
BHEEMAL	1.13	2.93	0.00	4.07	2.05
PAIYAN	0.20	0.00	0.00	0.20	0.10
GURIAL	0.93	0.00	0.00	0.93	0.47
MISC.	21.13	32.40	24.87	78.40	39.56
Total	25.87	63.47	108.87	198.20	100.00
Per cent	13.05	32.02	54.93		

Appendix 2: List of the prominent plant species of Pauri Garhwal.

	Local name	Botanical name
1.	Aam	Mangifera indica
2.	Aaru	Prunus persica
3.	Akhrot	Juglans regia
4.	Amaltash	Cassia fistula
5.	Amrud	Psidium guyava
6.	Amwla	Emblica officinallis
7.	Anaar	Punica granatum
8.	Asaine	Terminalia tomentosa
9.	Banj	Quercus leucotricophora
10.	Bakharu	Lonicera sp.
11.	Bans	Dendrocalamus strictus
12.	Bar	Ficus bengalensis
13.	Baryan	Zizyphus sativa
14.	Bedu	Salix spp.
15.	Bel	Aegle marmelos
16.	Belkar	Prinsepia utilis
17.	Bhaira	Terminalia belerica
18.	Bheemal	Grewia optiva
19.	Bhentra	Juniperous communis
20.	Burans	Rhododendron arboreum
21.	Chakotra	Citrus decumana
22.	Chanchri	Ficus gibbosa
23.	Charbi	Sapium sebiferum
24.	Cherry	Prunus cerasus
25.	Chhichhri	Pleetranthus rugosus
26.	Chichola	Albizzia lebbek
27.	Chimia	Macropanax oreophilom
28.	Chir	Pinus roxburghii
29.	Chula	Prunus armenica
30.	Daikarn	Melia azedarch
31.	Darwi	Cedrela serrata
32.	Deodar	Cedrus deodara
33.	Dharu	Punica sp.
34.	Dhaura	Anogeissus latifolia
35.	Gadanelli	Trema orientalis
36.	Gadaru	
37.	Gajla	
38.	Gald	Olea glandulifera
39.	Gauuta	Myrsine semiserrata

40. Genthi - Boehmeria regulosa
41. Ghoda - Vitex glabrata
42. Gogna - Saurauja nepalensis
43. Goi - Melisoma dilleniaefolia
44. Gonthia -
45. Gurial - Bauhinia purpurea
46. Haldu - Adina cardifolia
47. Hallyon -
48. Harra - Terminalia chebula
49. Jamun - Eugenia jambolana
50. Jhau - Tamarix gallica
51. Kachnaar - Bauhinia
52. Kail - Pinus
53. Kaiphal - Myric nagi
54. Kakaad - integerrima
55. Kangra - Loranthus longiferous
56. Kangu - Flacourtia ramontchi
57. Karmara - Averrhoa carambola
58. Karunda - Carisa spinarum
59. Kathal - Artocarpus integrifolia
60. Kathaman - Eugenia jambolana var. caryophyllifolia
61. Khair - Acacia catechu
62. Khajur - Phoenix sp.
63. Kharik - Celtis australis
64. Kharina -
65. Kheda -
66. Kiamal - Berberis spp.
67. Kingora - Berberis aristata
68. Klinna - Sapium insigne
69. Kubabol - Lucaena leucocephala
70. Kuri - Nyctanthes arbortristis
71. Kusuma - Schleichera trijuga
72. Lahod - Symplocos crataegoides
73. Lani - Suaeda sp.
74. Malta - Citrus aurantium var. Malta
75. Mandar - Acer caesium
76. Mohru - Quercus dilatata
77. Mohua - Bassia latifolia
78. Mola - Pyrus patia
79. Narangi - Citrus aurantium
80. Nashpati - Pyrus sinensis
81. Nimbu - Citrus medica
82. Pangarar - Erytherina indica
83. Papeeta - Carica papaya

84. Peepal - Ficus religiosa
85. Phalsa - Grewia asiatica
86. Phangar -
87. Pharsu - Grewia asiatica
88. Pina - Ehretia acuminata
89. Plaman - Syzygium cerasoides
90. Plum - Prunus cerasifera
91. Ramna - Acacia pinnata
92. Rara - Randia dumetorum
93. Reetha - Sapindous mukrosii
94. Safeda - Eucalyptus hybrid
95. Sal - Shorea robusta
96. Salu -
97. Samlan - Qugenia oojeinensis
98. Sandan - Ooginia dalbergidges
99. Santra - Citrus aurantium var.Santra
100. Seb - Pyrusmalus
101. Semal - Bombax ceiba
102. Semla - Bauhinia retusa
103. Shetut - Morus alba
104. Shka - Cornus macrophylla
105. Simali - Zizyphus sativa
106. Surai - Rosa involucrata
107. Suru - Pueraria tuberosa
108. Thanthra - Rhamnus virgatus
109. Tilfera - Cocculus lourifolus
110. Timla - Ficus roxburghii
111. Tour - Bauhinia vahlii
112. Tun - Cedrela toona
113. Tung - Rhus cotinus
114. Utis - Alnus nepalensis

Appendix 3. Stratum codification for scattered trees

S.No.	Stratum	Code
1.	Homestead	01
2.	Common land	02
3.	Agriculture land	03

Appendix 4. Girth class codification

S.No.	Girth class (m)	Code
1.	0.2 - 0.4	01
2.	0.4 - 0.6	02
3.	0.6 - 0.8	03
4.	0.8 - 1.0	04
5.	1.0 - 1.2	05
6.	1.2 - 1.4	06
7.	1.4 - 1.6	07
8.	1.6 - 1.8	08
9.	1.8 - 2.0	09
10.	2.0 - 2.2	10
11.	2.2 - 2.4	11

Appendix 5. Tree species codification

S.No	Species	Code
1.	Pinus roxburghii (Chir)	01
2.	Celtis australis (Kharik)	02
3.	Quercus leucotricophora (Banj)	03
4.	Cedrela toona (Tun)	04
5.	Ficus roxburghii (Timla)	05
6.	Rhododendron arboreum (Burans)	06
7.	Grewia optiva (Bheemal)	07
8.	Sapindus mukrosii (Reetha)	08
9.	Syzygium cerasoides (Paiyan)	09
10.	Boehmeria regulosa (Genthi)	10
11.	Bauhinia purpurea (Gurial)	11
12.	Sapium insigne (Khinna)	12
13.	Pieris ovalifolia (Ainyaar)	13
14.	Miscellaneous	14

APPENDIX VI: QUESTIONNAIRE FOR CONSUMPTION PATTERN STUDY IN PAURI GARHWAL 1991

A. VILLAGE DETAILS

1. Name: ------------------------ 2. Total number of families --

3. Distance of water source

a) Tank ------- b) River ------ c) Pipe ------

B. HOUSEHOLD DETAILS

1a. Name of the head---------------------, 1b.Father's name----------------

2. Electrified (Y=Yes, N=No)------,

3. Family Member------,

4. Total person popn. (permanent)-----------,

4.1 Popn. Men (15+)-----------, 4.2 Popn. Women (15+)------,
4.3 Popn. Children (15-)------,

5. Number of school going children------,

6.1 Number of Men (15+) who can read and write-----,

6.2 Number of Women (15+) who can read and write-----,

7.1 Primary occupation------------, 7.2 Secondary occupation------------,

C. FOOD CONSUMPTION AND COOKING METHODS

1. Average monthly per-household consumption of

Rice (Kg.)------, Wheat (Kg.)------, Pulses (Kg.)-------,

2a. Average daily per-household consumption of Milk (Kg.)------------,

3. Do you cook inside your kitchen (Y=yes; N=No)------,

3.1 Number of months cooking inside............,

3.2 Number of months cooking outside.......,

4. Number of meals in a day------,

5. Time spent in cooking daily (hrs.)------,

6. Type of utensils used (with type of material)-----------

--------------, ---------------, --------------,

6.1 Do you use a pressure cooker (Y=Yes, N=No) ....

D. CHULHAS OR COOKSTOVES PARTICULARS

Chulha			Types of energy sources used	Source of fuel	Which Govt. forest	Distance	Species used
Name	Material	No. of holes					
1							
2							
3							

Q.1. Do you face any problem during cooking? ....

....

Q.2 How many hours do you use the chulha for cooking in

Summer ...., Winter ....

Q.3 How many hours do you use the chulha for water heating in Winter ....

E. LIVESTOCK STATISTICS HOUSEHOLD

(A) (i)

Type of animals	Total no.	Stall-fed	Grazing	Type of fooder	Species used for fodder
Cows					
Calves					
Buffaloes					
Goats					

Sheep

Others

Note: (i) Total number of dungcakes made per day .....
*(ii) Average weight of dungcake (kgs.) ....

(ii) Fodder Consumption per Day

S.No.	Types of fodder	Quantity (People) (A)	Check (B)
1.	Grasses		
2.	Shrub		
3.	Trees		
4.	Crop Residues		

Total consumption = ΣA
Per Capita = ΣA/number of family members

(c) (iii) Uses of Cowdung

S.No.	Total dung produced	Uses (Quantity)					Uses (Cross Check)				
		Cake	Manure	Sale	Plaster	Any Other	Cake	Manure	Sale	Plaster	Any Other

F. DOMESTIC ENERGY CONSUMPTION

Fuel Type	Unit	Cooking + Water heating			Space heating			Lighting			Total		
		S	W	M	S	W	M	S	W	M	S	W	M
Dung cake	Nos/day												
Firewood : logs	Kg/day												
Firewood : Twigs/branches	Kg/day												
Crop residue	Kg/day												
Soft Coke	Kg/day												
Kerosene	Lit/month												
Electricity	kwh/month												
LPG	Cylinders/month												

Quantity of different biomass used for various enduses

Name of material	Use of Thatch		Thatched area (if any)	Use of bedding material		Timber consumed/year			Endusewise	
	By people	Check		People	Check	Qty.	Freq.	Source	Furniture	Bld. material
Grasses										
Crop residues										
Shrub										
Trees										
Cow dung										

G. AGRICULTURAL ENERGETICS FOR ONE CYCLE OF CROP PRODUCTION

Please report for the crops you had grown in the last one year in different seasons

Description	RABI			
	A	B	C	D
Crop Particulars				
1. Crops grown (if mixed cropping Pl.specify)				
2. HYV/traditional (h/t)				
3. Area covered (Nali)				
4. Area under irrigation				
5. Source of irrigation				
6. Uses of Crop Residues				
7. Productivity (Kg./Nali) under (i) irrigated land (ii) unirrigated land (for different crops)				

Collection source (type of land)

H.2 Preparation of Dung

Particulars	Summer	Monsoon	Winter
No. of dungcakes made weekly			
Average weight of a dry dungcake (kg)			
Quantity of dung used as direct manure (qtl/nali)			
Quantity used for HH use (construction, plastering) (kg)			
Quantity of dung sold (kg)			

H.3 Collection of grasses per person per day -----------------

Average weight of grasses per trip -----------------------

Description	KHARIF A	B	C	D
Crop Particulars				
1. Crops grown (if mixed cropping Pl.specify)				
2. HYV/traditional (h/t)				
3. Area covered (Nali)				
4. Area under irrigation				
5. Source of irrigation				
6. Uses of Crop Residues				
7. Productivity (Kg./Nali) under (i) irrigated land (ii) unirrigated land (for different crops)				

H. COLLECTION AND PREPARATION OF BIOMASS

H.1 Collection of Wood

Particulars	Summer	Monsoon	Winter
No. of persons collecting			
No. of collection days per week			
No. of trips made by one person in a day			
Total quantity collected per person per trip (kg)			
Distance travelled per trip for collection (km)			

I. SCARCITY INDICATORS (Y=Yes, N=No)

1) Do you perceive fuel wood scarcity? YES/NO

2) Does the present firewood consumption vary from the past? YES/NO

2.1) If so, has it increased/decreased? Increased/Decreased

3) Has the no. of persons collecting gone up? YES/NO
By how many?

4) Has the no. of collection trips per week gone up? YES/NO

5) Whether fuel is purchased/collected for special requirements (festivals, marriages?)

6) What do you think are the reasons for fuel scarcity?

a............................

b............................

c............................

7) What should be done to reduce scarcity?

a............................

b............................

c............................

Appendix 7. Regression equations used for height and volume computation

Species	Height	Volume
1. Burans (Rhodendrum arboreum)	3.319529 + 3.525574*G	$-0.0026 + 0.03762^{*} G^2H$
2. Timla (Ficus roxburghii)	2.878462 + 3.578325*G	$-0.0026 + 0.0461^{*} G^2H$
3. Banj (Quercus leucotrichophora)	2.784689 + 3.879138*G	$-0.0012 + 0.04245^{*} G^2H$
4. Bheemal (Grewia optira)	2.972410 + 4.903643*G	$-0.0054 + 0.03642^{*} G^2H$
5. Kharik	2.972410 + 4.903643*G	$-0.0054 + 0.03642^{*} G^2H$
6. Tun (Cedrela toona)	3.581754 + 4.036010*G	$-0.0032 + 0.03854^{*} G^2H$
7. Reetha (Sapinodous mukrosii)	2.423328 + 4.696997*G	$-0.0018 + 0.0413^{*} G^2H$
8. Paiyan (Syzygium cerasoides)	2.062419 + 6.832168*G	$-0.007683 + 0.0547179 D^2H$
9. Genthi (Boehmeria rugulosa)	- 0.02132 + 8.679112*G	$0.07055 + 0.471211 D^2H$
10. Gurial (Bauhinia purpurea)	3.124372 + 6.826221*G	$0.07055 + 0.471211 D^2H$
11. Khinna (Sapium insigne)	2.393816 + 7.235686*G	$-0.007683 + 0.0547179 D^2H$
12. Ainyaar (Pieris ovalifolia)	1.077553 + 8.419118*G	$0.016615 + 0.47929 D^2H$
13. Chir (Pinus roxburghii)	- 0.13559 + 11.52437*G	$0.0789 + 0.3047 D^2H$
14. Others		$-0.2151 + 3.562^{*} D$